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OF THE

## South-Eastern Agricultural College

WYE, KENT

*Edited for the College by*

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# EDITORIAL

The reports appearing in this issue of the *Journal* cover the period of the 1932-33 session and signalize much progress in many branches of the work of the College.

I am indebted to Mr. L. W. L. Cole for preparing the index to this *Report Number*.

S. Graham Brade-Birks.

# CONTENTS

# DEPARTMENT OF ENTOMOLOGY

By S. G. Jary and M. D. Austin.

Advisory Work. The volume of this type of work continues to grow and the number of enquiries received during the past year has totalled over 200, to which must be added many more dealt with personally when growers visit the Department or when visits are made to farms. The County Agricultural and Horticultural staffs in the Province have supplied much information and many queries in which those of a horticultural nature predominate.

## A SURVEY OF THE OCCURRENCE OF THE MORE IMPORTANT PESTS.

Cereals. Numerous cases of damage by Wireworms, *Agriotes* spp., occurred all over the Province. In places wheat was severely thinned and some fields of oats and barley had to be ploughed up. This is the second successive year of bad attacks. Of the other common pests, Slugs, mainly *Agrolimax agrestis*, were destructive to wheat in January, but Leather Jackets (*Tipula* spp.), the Frit Fly (*Oscinella frit*) and the Goutfly (*Chlorops taeniopus*) were all scarce. The Grain Weevil (*Calandra granaria*) occurred in stored grain in Sussex and the Corn Cockle Eelworm (*Anguillulina dipsaci*) was observed in places in Surrey.

Potatoes. Throughout the Province, "potato sickness" associated with the Eelworm (*Heterodera schachtii*) has become widespread and severe, rendering cropping with potatoes almost impossible on many allotments and areas of intensive cultivation. The Stem Borer (*Hydroecia micacea*) was common in the Isle of Sheppey and caterpillars of the Death's Head Hawk Moth (*Acherontia atropos*) were unusually abundant. A small outbreak of the Colorado Beetle (*Leptinotarsa decemlineata*) occurred at Tilbury, Essex, in August and precautionary spraying of potato crops was carried out by the Ministry of Agriculture and Fisheries on the Kent side of the Thames around Gravesend.

Pulse and Clovers. The increasing acreage of peas grown for canning purposes has attracted some attention to the pests of this crop. The Green Pea Aphis (*Macrosiphum pisi*) was very common just before harvest and caused some concern, while Millipedes (*Blaniulus guttulatus*) caused damage to seedlings in Romney Marsh. The Pea Thrips (*Frankliniella robusta*) was again destructive on late crops and the Pea Moth (*Cydia nigricana*) rather more common than last year. Pea and Bean Weevils (*Sitones* spp.) caused no great damage. Larvae of the fly *Chortophila cilicrura* caused injury to dwarf French beans in Sussex.

Mangolds and Sugar Beet. No instance of insect pest attacks was recorded on these crops. The Pigmy Mangold Beetle (*Atomaria linearis*) and the Mangold Fly (*Pegomyia hyoscyami* var. *betae*) were apparently of no importance.

Brassicae. Flea Beetles (*Phyllotreta* spp.) proved troublesome on kale and earlier sown crops, but attacks were not of more than average intensity. The Cabbage Stem

Flea Beetle (*Psylliodes chrysocephala*) occurred in numbers in North Kent where the Root Gall Weevil (*Ceuthorrhynchus pleurostigma*) was also plentiful. Some bad attacks by the Mealy Cabbage Aphis (*Brevicoryne brassicae*) were recorded and seem to have been general in the Province. The Cabbage White Butterflies (*Pieris brassicae* and *P. rapae*) were very plentiful and severe damage was done by their caterpillars. Cabbage Root Fly (*Chortophila brassicae*) remained about normal in intensity and Diamond Back Moth (*Plutella maculipennis*) was scarce. Infestations by the Cabbage White Fly (*Aleurodes brassicae*) were commonly reported.

OTHER VEGETABLE PESTS. The Onion Fly (*Hylemyia antiqua*), Carrot Fly (*Psila rosae*) and Celery Fly (*Acidia heraclei*) occurred commonly in places but were not unusually severe. Equally as important as the Carrot Fly on many allotments in Sussex was the aphis *Cavariella* spp. which was responsible for much loss. The larvae of the Cockchafer (*Melolontha vulgaris*) caused havoc among all kinds of plants in parts of Surrey and adult beetles were very common on the wing in May. Two instances of severe damage by the Asparagus Beetle (*Crioceris asparagi*) were recorded from Surrey.

FRUIT. The Apple Blossom Weevil (*Anthonomous pomorum*) was again widespread and destructive. Serious attacks on pears were also seen and newly emerged weevils were observed boring into apple fruitlets. Fruit tree aphides were below normal, except the Leaf Curling Plum Aphis (*Anuraphis helichrysi*) which was common in places. With the common species on apple, the number of winter eggs on trees was small and there were few early attacks, though the Green Apple Aphis (*Aphis pomi*) was occasionally abundant on young trees. The Woolly Aphis (*Eriosoma lanigerum*) became abundant early in the season and some bad attacks developed, but the insects tended to die out in late summer and many colonies disappeared at a time when they are normally strongest. In one case wasps were noted carrying off these aphides. In most places Winter Moth infestations (*Cheimatobia brumata*) and other species were not heavy and leaf eating species of *Tortricidae* were not more than normally abundant. The Apple Capsid Bug (*Plesiocoris rugicollis*) continued to be a most serious pest. Many cases occurred in which winter washing with petroleum oils failed to give a control. The Common Green Capsid (*Lygus pabulinus*) was abundant ; pear fruits were severely marked by this species in Kent and the foliage of gooseberries, currants and cultivated blackberries also badly attacked. Leaf-eating Weevils, chiefly *Phyllobius pyri* and *P. oblongus*, caused damage in nurseries and to newly planted trees, while the Clay-coloured Weevil (*Otiorrhynchus singularis*) was very destructive in a similar way. The Apple Twig Cutter (*Rhynchites coeruleus*) and the related *Rhynchites aequatus* were common, the latter causing marked injury to apple fruitlets in the Swanley and Faversham areas. The Apple Fruit Sawfly (*Hoplocampa testudinea*) remains a most serious pest and attacks of great severity occurred. Damage by the second brood larvae of the Codlin Moth (*Cydia pomonella*) also appears to be increasing. The Apple Fruit Miner (*Argyresthia conjugella*), which was so abundant near Canterbury in 1932, was almost absent from apples this season though very plentiful on the berries of Mountain Ash in adjoining woods.

Larvae of the Tortrix Moth (*Batodes angustiorana*) were common on apples at the time of picking, but probably not quite as numerous as last season. Attacks by the Fruit Tree Red Spider (*Oligonychus ulmi*) occurred in many places but few of great severity were seen. The Plum Fruit Sawfly (*Hoplocampa flava*) caused heavy losses on Czar plum in some areas and locally the Pear Midge (*Contarinia pyrivora*) was abundant. On raspberries the Clay-coloured Weevil (*Otiorrhynchus singularis*) was destructive and

was in general much more prevalent than normally The Raspberry Beetle (*Byturus tomentosus*) was abundant early in the season, but the damage done by it was not so common as last year, probably owing to the vigorous adoption of control measures by most growers. Gooseberry and Currant Aphides were not abundant but a few cases of serious infestation by the Currant Clearwing Moth (*Aegeria tipuliformis*) were reported. On cultivated blackberries the mite, *Eriophyes essegi*, causing " Red berry ", was reported from Sussex and the aphis *Macrosiphum rubiellum* was very common. Strawberries were commonly infested by the Strawberry Mite (*Tarsonemus fragariae*) and the Strawberry Blossom Weevil (*Anthonomous rubi*) did much damage in Sussex and was also reported to be increasing in parts of Kent. The Eelworm (*Aphelenchus ribes*) caused damage on black currants in Sussex, the variety September Black suffering most severely.

HOPS. The outstanding pest of the year has been the Red Spider (*Tetranychus telarius*), which became everywhere abundant in late July and August during hot dry weather. Attacks by the Hop-Damson Aphis (*Phorodon humuli*) were not of more than average intensity and small infestations by the Capsid Bug (*Calocoris norvegicus*) occurred.

MUSHROOMS. Five different species of flies of the genus Sciara have been found attacking mushrooms as well as species of Phora, Drosophila and the family Cecidomyidae. The Mushroom Mite (*Tyroglyphus mycophagus*), various Springtails (*Collembola*) and Woodlice (*Oniscidae*) have been found causing damage. Further reference is made to these pests below.

FLOWERS. Heavy infestations by the Chrysanthemum Eelworm (*Aphelenchus ritzema-bosi*) were widespread and the aphis *Macrosiphoniella sanborni* also occurred. Bulbs were heavily infested by the Small Narcissus Fly (*Eumerus* spp.) in Surrey and the Large Narcissus Fly (*Merodon equestris*) was observed to be common on the wing during the summer. Much damage was done to pot plants by the larvae of the Clay-coloured Weevil (*Otiorrhynchus singularis*). Infestations by the Eelworm (*Anguillulina dipsaci*) on perennial phlox were also common.

MISCELLANEOUS. Reports of infestations by the Death Watch Beetle (*Xestobium rufovillosum*) continue to be received. Fleas (*Pulex irritans*) associated with orchards in which pigs are kept have proved a nuisance to fruit pickers in places. The Nut Weevil (*Balaninus nucum*) has been very common. Household insects have been reported, Woodlice as very abundant in places, Earwigs in some localities and *Lepisma saccharina* has been more than usually plentiful. Wasps on the whole have not been abundant.

## GENERAL OBSERVATIONS.

The interest in fruit tree protection against insect pests noted as a prominent feature last year has again been in evidence, as may be gathered from the number of enquiries received. There has also been a great increase in enquiries relating to mushroom pests. A feature of the year has been the failure to obtain a satisfactory control of the apple capsid bug in many cases, by the use of petroleum oil winter washes which have hitherto been successful in this respect. The year has also been marked by the great prevalence of weevils in general, but aphides have been abnormally scarce, particularly on fruit trees, though certain species on peas and blackberries were abundant.

Most species of aphides, however, suffered great mortality during July, in a period of heavy thunder rains alternating with hot weather. Besides parasites and predators, which were active, the weather apparently favoured the incidence of certain fungus attacks upon aphides and large and flourishing colonies disappeared very rapidly. Of the vegetable pests, cabbage white butterflies were extremely common in the summer, and great numbers of eggs were laid, but probably owing to local climatic conditions the numbers of larvae subsequently found were very small. The potato eelworm, associated with "potato sickness", is now widespread in the Province and local authorities in places have been asked to enquire if any action can be taken. Among cereal pests, only wireworm attacks have been abnormally bad, most of the others being scarce.

## EXPERIMENTAL WORK.

1. Control of the Strawberry Blossom Weevil (*Anthonomous rubi* Herbst).

Laboratory and field experiments have been continued on the control of this insect. In the field, arsenic-sulphur dusts and dusts containing Rotenone have been employed but have not given results which justify their recommendation to the grower. This is particularly the case with the arsenic-containing dusts which are considered as dangerous owing to the amount of arsenic remaining on the fruits. Laboratory experiments were made with the same two dusts as above and in addition various Pyrethrum extracts, Barium fluosilicate and certain new proprietary insecticidal substances were tested. Under the conditions of experiment none of the substances showed any consistent toxic action upon the weevils.

2. The Ovicidal Action of Various Oil Emulsions as Winter Washes.

This work, carried out in co-operation with the Chemical Research Department, has been continued on the same general lines as in the two previous years. The laboratory tests as before have been done on rooted currant cuttings containing the eggs of *Lygus pabulinus*, the Common Green Capsid Bug and over thirty oil combinations have been employed. Field trials on currants against the eggs of the same insect and on apples against the eggs of the Apple Capsid Bug (*Plesiocoris rugicollis*) have also been continued.

The tar-petroleum wash which has previously given very satisfactory results against the Common Green Capsid on currants has been used commercially by two growers on fields totalling about 20 acres of red and black currants. The results have been consistently good and the degree of control obtained very high. In one case the wash was made up to specification by a firm of insecticide manufacturers and in the other the materials were purchased by the grower and the wash made up in the field.

3. Some New Insecticides and Insecticide-Fungicide Combinations.

This work again has been to some extent a continuation of that reported last year, but no field scale trial has been included. The Hop-Damson Aphis (*Phorodon humuli*), the Nettle Aphis (*Macrosiphum urticae*) and the Bean Aphis (*Aphis rumicis*) have mainly been used as test insects but a number of trials on the Fruit Tree Red Spider (*Oligonychus ulmi*) have been included. The experiments were all of the precision type, involving actual counts of the numbers of insects and mites and about twenty-five different substances, spread over some 150 tests, have been used. Many of these were

new contact insecticides, or substances considered to be worth testing from the point of view of their possible use as insecticides, and were proprietary articles. Mr. J. H. Stapley has largely been responsible for the work which has been carried out with the aid of a grant from Imperial Chemical Industries Limited, and the Chemical Research Department has co-operated as last year.

4. PYRETHRUM.

The fourth crop has been harvested from the experimental plot of pyrethrum and has proved to be somewhat heavier than last year. The Botanical Department has co-operated in work on the selection of types of plants suitable for propagation, the characters desired being a suitable habit of growth, size of flowers, etc. In addition a series of plots has been laid down in which plants have been set out at different distances apart, in order to study the effect on yield and on the habit of growth.

5. THE USE OF *Aphelinus mali*, A PARASITE OF THE WOOLLY APHIS (*Eriosoma lanigerum*) IN THE FIELD.

Material of this parasite, supplied by the Plant Pathological Laboratory of the Ministry of Agriculture and Fisheries, has been introduced into two orchards in an attempt to control Woolly Aphis attacks. In both cases the parasite has become firmly established and has spread to most other affected trees in the orchards concerned.

6. THE LIFE HISTORY AND CONTROL OF THE APPLE FRUIT MINER (*Argyresthia conjugella*).

Owing to the serious nature of attacks in the vicinity of Canterbury last year, it was decided to study this insect. Frequent observations were made in affected orchards and neighbouring woods and from material collected the life history was followed through in the laboratory. The attack in the field was negligible this year on apples, but the berries of Mountain Ash were plentiful in the vicinity and the attack was common on them. This is in accordance with experience in Sweden. Preliminary control experiments were carried out in the laboratory with success.

7. INSECT AND ALLIED PESTS OF CULTIVATED MUSHROOMS AND THEIR CONTROL.

A marked increase in enquiries relating to pests of mushrooms has occurred with the expansion of this industry in the country. Material for examination has been received from several English counties and also from Wales and Scotland. In the majority of cases when attacked mushrooms have been received, fly larvae have been the cause of damage. Various species of *Sciara* appear to occur throughout the year and have been the most common insects noted, but in the summer months certain flies of the family *Phoridae* are also abundant. In addition, certain Mites, Woodlice, Springtails, Slugs and some flies of the families *Drosophilidae* and *Cecidomyidae* have also caused damage.

Investigations have mainly been concentrated on the biology of *Sciara* spp. and in particular *Sciara fenestralis*, a species not hitherto recorded on mushrooms. The life cycle is short, being completed in from twenty-nine to forty-four days and a series of attacks may therefore take place during the cropping period of a mushroom bed. Certain species of *Phora* have also been studied.

Control methods on a laboratory scale and also on beds on the College Farm have been carried out, using Nicotine, Derris and Pyrethrum products. It would appear that

Nicotine used in the early stages of attack by *Sciara* spp. will give a considerable degree of freedom. Pyrethrum also promises to be worth further investigation, especially in certain cases.

Contact has been made with workers in U.S.A. on this subject and much valuable help has been given in the identification of pests by the British Museum of Natural History, by Mr. A. M. Massee, East Malling Research Station and other independent workers.

Mr. M. D. Austin has been responsible for this work.

8. Experiments on the Control of the Potato Eelworm (*Heterodera schachtii*).

Attempts to control this eelworm were made at two centres, one in Surrey and the other in Sussex, using crude naphthalene on the lines of experiments carried out elsewhere in the country. The soil was treated with crude naphthalene (Drained Creosote Salts) which was ploughed in to a depth of about 7 inches a fortnight before planting, a dressing of 6 cwt. per acre being employed. In part of one experiment an equal quantity of hydrated lime was mixed with the naphthalene. In neither case was appreciable benefit derived from the treatment and the crop was little better than that obtained from neighbouring untreated soil, the attack by eelworm being heavy, though cysts were not quite as numerous on the treated plots. On the soils in question it would appear that this treatment does not give results which warrant the expenditure entailed.

9. The Control of Wireworms in New Gardens.

The gardens of some newly built houses, on old pasture, were found to contain a wireworm population of at least 100 to the square yard of soil taken to a depth of about 9 inches. Plants of all kinds put in were rapidly destroyed and an attempt was made to deal with the infestation. A proprietary soil insecticide was employed and dug in at the rate of 4 oz. to the square yard and the ground somewhat consolidated on 1 June. On 6 June a random square yard about 9 inches deep was dug out, and carefully sifted. The following results were obtained :—

| | |
|---|---|
| Wireworms dead | 46 |
| Capable of very slight movement | 11 |
| Slightly more active but incapable of moving in soil | 2 |
| Total | 59 |

It should be noted that many wireworms had previously been removed by hand from this ground. The treatment had an adverse effect on seeds sown later, but it is considered that this may afford the most expeditious method of clearing newly broken land, which normally remains infested for some years and a smaller dosage might be worth trial.

## EDUCATIONAL WORK.

### Lectures in College.

A complete course of lectures has been given to agricultural and horticultural students in economic entomology, and some additional work has been done with B.Sc. students who have been accommodated in the laboratory.

EXTRA MURAL LECTURES.

During the winter months, eleven lectures were given to various societies in Kent and one in Surrey.

EXHIBITS AT SHOWS, ETC.

An exhibit dealing with the insect pests controlled by winter washes was staged at the Kent County Show, Maidstone, and material supplied to the Ministry of Agriculture for exhibits at the Bath and West Show, Wimbledon. Periodic notes on insect pests have been contributed to the *Journal* of the Kent Branch, N.F.U. A complete spraying programme against insect pests has been carried through in co-operation with the other Departments concerned, on the demonstration plot at West Farleigh.

CONFERENCES, ETC.

The Annual Conference of Advisory Entomologists was attended at Long Ashton and four Provincial Conferences have been attended during the year, as well as a number of meetings of the Kent Branch N.F.U. Fruit and Vegetable Committee, when matters of importance from an entomological standpoint have been on the agenda.

## PUBLICATIONS.

1. Austin, M.D., Jary, S. G., and Martin, H. "SOME NEW INSECTICIDES AND POSSIBLE INSECTICIDE-FUNGICIDE COMBINATIONS." *Horticultural Association Year Book*, Vol. 1, 1932.

An account is given of trials carried out on the control of the Apple Fruit Sawfly (*Hoplocampa testudinea*), using Bordeaux mixture and various contact insecticides in combination, and also with similar washes against the Hop-Damson Aphis (*Phorodon humuli*).

2. Austin, M. D., Jary, S. G., and Martin, H. "STUDIES ON THE OVICIDAL ACTION OF WINTER WASHES." *Jour. S.E. Agric. Coll.*, No. 32, pp. 63-83.

Field and laboratory trials are described, involving the use of a number of oil emulsions, on lines similar to those carried out in 1931.

3. Austin, M. D., and Martin, H. "THE INCORPORATION OF CONTACT INSECTICIDES WITH PROTECTIVE FUNGICIDES. POTATO FIELD TRIALS, 1930-2." *Jour. S.E. Agric. Coll.*, No. 32, pp. 49-58.

Washes containing Nicotine or Pyrethrum were used in conjunction with Bordeaux mixture on potatoes for the conjoint control of Potato Blight (*Phytophthora infestans*) and insects concerned with the transmission of potato virus diseases, with the object of determining whether such washing would prevent the deterioration of home saved seed tubers. The crop obtained from seed tubers saved from washed plots was significantly greater than that obtained when seed was saved from untreated plots.

4. Austin, M. D. "A NOTE ON *Lygus pabulinus* L." *Jour. S.E. Agric. Coll.*, No. 32, pp. 168-70.

The habit of this capsid of laying winter eggs in cultivated blackberry is described and the increasing prevalence of early attacks on these plants noted.

5. Austin, M. D., and Jary, S. G. " INVESTIGATIONS ON THE INSECT AND ALLIED PESTS OF CULTIVATED MUSHROOMS. (1) *Sciara fenestralis* Zett." *Jour. S.E. Agric. Coll.*, No. 32, pp. 59-62.

The species of the genus *Sciara* previously recorded as attacking cultivated mushrooms are noted and a hitherto unrecorded mushroom infesting species, *S. fenestralis*, described. The life history has been followed out and control measures are summarized.

6. Austin, M. D. " THE INSECT AND ALLIED FAUNA OF CULTIVATED MUSHROOMS (1)." *Entomologists' Monthly Mag.*, Vol. lxix., Jan. 1933, pp. 16-19, and (2) Vol. lxix., June 1933, pp. 132-4.

Lists are given of insects and allied pests noted as attacking cultivated mushrooms. The occurrence of hymenopterous parasites associated with certain *Diptera* is noted.

# DEPARTMENT OF MYCOLOGY

By Prof. E. S. Salmon and W. M. Ware.

Advisory and Educational Work.

On 11 January, at the Hop Growers' Conference held at Wye College, which over 160 growers attended, we read papers on " Some Aspects of the Hop Downy Mildew Problem ". On 5 July we took part in the Conference of the Virus Diseases of Plants Committee and Workers, at Rothamsted.

On 27 April we attended a meeting held at Wye College to discuss the subject of " Marsh Spot in Peas ". Dr. G. H. Pethybridge, Mycologist to the Ministry of Agriculture, was in the chair. Representatives of the Seed Trade attended. Mr. S. J. Travers, Assistant Agricultural Organizer, and Mr. B. S. Furneaux were present and agreed to undertake an investigation into the occurrence of Marsh Spot in relation to the soils of Romney Marsh. Mr. Travers immediately made arrangements with seeds firms and contract growers and samples of the seed used on the various fields were saved. Mr. Furneaux surveyed the soils of about eighty different fields and, through co-operation on the part of the growers with both Mr. Travers and Mr. Furneaux, the latter were enabled to collect pods from the crops just before they were carried. It was found that different soil-types often occurred in one and the same field and in consequence over 100 samples of the crops have been collected and dried. The quantity and type of Marsh Spot present will next be determined. The potash content of many of the soils has been determined by Dr. W. Goodwin.

Prof. Salmon was present at the " Visitors' Days " at East Malling Research Station on 30 August and 6 September, and demonstrated the New Varieties of hops grown there, and attended the Hops Sub-Committee on the latter date.

Mr. Ware attended the Phytopathological Meeting of the British Mycological Society at the Herbarium, Kew, and at the Imperial Mycological Institute, Kew, and exhibited specimens of Mushroom Bed invaders (*Oospora fimicola*, *Clitocybe dealbata* and *Xylaria* sp.).

Mr. Ware lectured on Mushroom Growing to the Lewes (Sussex) Branch of the N.F.U. on 7 December and on the same subject to members of the H.E.A. at the Chelsea Physic Garden on 25 May. On 18 January he attended the Wye Provincial Horticultural Conference in London and opened a discussion on Mushroom Growing.

Mr. Ware attended, on 21 January, the Meeting of the British Mycological Society in London, and the Meeting of the Association of Economic Biologists on 24 February.

Courses of Lectures on Fungus Diseases of Plants have been given by Prof. Salmon to students at the College in the B.Sc. Horticulture, Diploma and Certificate Courses. Mr. Ware gave a course of practical work to the students taking the B.Sc. Horticulture course, and a number of lectures to gardeners and others in towns and villages in Kent.

Exhibits of Fungous Diseases of Fruit and Hops were prepared for the Kent Agricultural Show at Maidstone, and for the Bath and West and Southern Counties Show at Wimbledon.

The following is a brief account of a few of the numerous specimens of diseased plants received for examination or of cases investigated during the year. CEREALS.—*Cladosporium herbarum* on the ears of wheat (Hybrid 23) was suspected by a farmer in North Kent to have been seed-borne and evidence was produced. The conditions under which wheat becomes attacked by this fungus have been studied and described by Dr. F. T. Bennett (*Ann. Appl. Biol.*, XV, No. 2, 191-212, May 1928) who shows that there is no direct transference of the disease from seed to crop *via* the embryo but that the fungus is a weak parasite which is likely to occur externally on any badly-grown or badly-harvested plants. If such infected grain is used for seed it is likely to produce weak plants (unless growing conditions are perfect) and weak plants are particularly liable to attack by *Cladosporium* on the ear. Infected seed may therefore be an indirect but certainly not the direct cause of the appearance of the fungus on the ears of the resulting crop. POTATOES.—On 10 May specimens were received from Gloucestershire which showed *Rhizoctonia solani* causing a rot of the shoots (1-4 inches long) before they came through the ground ; the grower reported that this was occurring in all his potatoes which had been planted early (in the last half of March) including early varieties (Sharpe's Express) and late varieties (King Edward, Majestic, Arran Banner) and was causing bad gaps in the rows. The loss of shoots was said to be less serious in the late varieties because there was time for recovery. At Wye, Kent, Leaf-Roll was noted throughout a crop of the variety Dunbar Cavalier grown from seed direct from Scotland. Blight (*Phytophthora infestans*) was first seen on 18 July at Wye on the variety King Edward ; in the area generally it was unable to cause much damage to the haulm owing to the exceptionally dry summer. In the Romney Marsh district a few fields of potatoes showed more serious consequences of Blight attack on the haulm, but this was unusual and the year will be remembered as one in which the fungus caused a minimum of damage. PULSE.—Runner bean plants from a glasshouse in Sussex were received in March. These were attacked by *Fusarium* sp. causing a trouble similar to the " Foot-rot " described from the U.S.A. About 50 per cent. of the plants being grown were attacked ; they showed a definite canker at the base of the stem and a brown sunken line extended up one side of the stem to a height of 6 cm. above ground. On crops of culinary peas, in spite of the dry season, Downy Mildew (*Peronospora Viciae*) flourished on the leaves but little damage was done. On 22 June an interesting form of injury to the pods, caused by hail, was brought to our notice. This consisted of white or pale green irregular spots scattered on one side only of the pods. Near Challock, Kent, on 3 July, about 4 acres of a crop of 7 acres of peas being grown on contract for seed was in process of being ploughed in. The plants were brown and withered owing to stem-rot at and below ground level ; they were 18 inches high, in flower or starting to form pods. A species of *Fusarium* was isolated. One further case on 13 July occurred in 6 acres of peas between Wittersham and Tenterden, Kent, when the pods were nearly ripe and others just filling. Marsh Spot (cause unknown) was first seen in green peas, nearly full grown but as yet immature in the pod, at the end of July. An enquiry into the occurrence of Marsh Spot has been carried out during the past summer and is mentioned elsewhere in this Report. GRASSES.—On 1 November a sample of turf cut from a golf green was sent. This was of very brown colour due to the dead and decaying condition of the minute lower leaves and sheaths. Only the youngest leaf on each small stem was green. It was said that the trouble occurred in patches and that complete recovery

took place in spring. At the base of the plants, hyphae of *Rhizoctonia* sp. were constantly present and no other possible cause of the brown patches was found. *Corticium fuciforme* was present on grasses in a sample turf cut from a lawn at East Grinstead on 20 July. The grass had withstood the drought but had turned brown immediately after a rainy spell.

BRASSICAE.—Ring Spot (*Mycosphaerella brassicicola*) was sent in from Lewes in October on the leaves of broccoli and in November from Croydon. The latter case was of interest because both pycnidia and perithecia were present, as described in *Report on Economic Mycology*, 1913-14, S.E.A. College, Wye, and *Jour. S.E. Agric. Coll.*, No. 22, p. 455, 1913. Smoky-grey coloured rings on the leaves of Brussels sprouts from Wye were examined but no organism could be found associated. They occurred on only a few plants in a two-acre field so were probably not the direct result of *Aphis* punctures; they originated, however, as single black pin-point spots. In January our attention was called to damage caused by *Botrytis* to the growing point or terminal bud of Brussels sprouts. The elongation of the stem was prevented because the " head " of the stem was converted into a soft brown decaying mass. A few of the lateral " sprouts " were affected externally; in addition a few were found which, though green externally, were brown internally. This could not be connected with the *Botrytis* attack. It was a particular nuisance to the grower who anticipated possible trouble with the salesmen. On 15 November *Erysiphe Polygoni* on Curly Kale (*Brassica oleracea acephala*) was received from East Grinstead. This form of the fungus had unusually long cylindrical conidia measuring $40\text{-}74\mu \times 14\text{-}16\mu$. VEGETABLES.—On 25 January from Hurstpierpoint, Sussex, carrots were received which showed large sunken black areas on which the skin was unbroken and smooth. Internally the black rotting affected the cortex down to the vascular cylinder or involved the whole root. Three fungi were isolated, one of them being *Alternaria* sp. It is hoped to carry out further investigations with this fungus which may prove to be the *A. radicina* of Meier, Drechsler and Eddy (*Phytopathology*, XII, No. 4, 157-66, 1922) which they describe as the cause of Black Rot of carrots. On lettuces, besides *Botrytis cinerea* and *Bacterium marginale*, *Macrosporium sarcinula* (a stage of *Pleospora herbarum*) was received. The disease, described by Ogilvie and Mulligan (*Gard. Chron.*, 10 January 1931) was on outdoor cabbage lettuce plants sent in May from Devon. The grower had cut about 2,000 plants when the remainder of the planting was spoiled by the disease within a few days. " Balloon " Cos lettuces sent in in August were thought to be affected with a virus disease; the young inner leaves were much wrinkled or blistered but mottling was not apparent. A brown colour at the margins of these leaves originated as minute, rather angular, spots. Seed from which these plants were grown has been saved. The specimens came from near Lancing, Sussex, and within a few days others (variety Cos Mammoth White), showing the same symptoms, were received from Scaynes Hill, Sussex. On outdoor tomato plants (probably self-sown) *Phytophthora infestans* was noted as late as 8 October. Several cases of Foot Rot (*Phytophthora* spp.) were met with in the earlier part of the season and the physiological trouble known as " Green Back " throughout the very hot summer. Several cases of Spotted Wilt (virus) and Stripe (virus) were received. On onions, both *Sclerotium cepivorum* and *Peronospora Schleideni* occurred; for the control of the latter an efficient spreader for Bordeaux mixture is very much needed.

FRUIT.—APPLES.—The sun-scorch mentioned in this *Journal* (No. 31, p. 15, January 1933) as occurring on Bramley's Seedling and Allington Pippin was described

and illustrated in an article (1) published in October. Subsequently it was found that the variety Newton Wonder at Wye had also been affected; additional localities were Bunny, Notts (Bramley's) and Crowborough, Sussex (Allingtons). It is remarkable that in the hot and dry season of 1933 no instance of this form of damage has been brought to our notice. Frost, on the other hand, had an effect on Bramley's Seedling, for in one orchard at least (at East Farleigh, Kent) numerous apples on 1 August were showing the typical ring mark around the "eye" such as was illustrated in a former article (*Gard. Chron.*, LXXXII, p. 154, 1927). Dry conditions between 21 March and 24 April delayed the appearance of Scab but later in the season the disease assumed its usual intensity on the foliage; the very hot and dry summer, however, assisted in the production of one of the best quality apple crops that have been grown. Mature ascospores of the fungus (*Venturia inaequalis*) were being ejected from dead leaves on 9 May and it was not until 13 May that any conspicuous attack on the new foliage was noticed. "Eye-rot" of the variety Worcester Pearmain (this *Journal*, No. 31, p. 14, January 1933) was again met with, on 14 August, affecting nearly all the ripe fruit on a large tree in an orchard at Bearsted, Kent. In 1933, the early appearance of sporophores of *Armillaria mellea* at the base of old apple trees in a mixed orchard, was noted on 29 September. PEARS.—Mature conidia of the Pear Scab fungus were found on 15 March on the spur wood of Louise Bonne and at the base of the wood buds. Dead leaves picked up at this date contained perithecia (*Venturia pirina*) in which many of the asci were mature and ejected ascospores. The variety Conference which, as pointed out in our report of last year, is regarded as resistant to Scab, was again quite generally attacked by the fungus in 1933. As early as 12 April the *Fusicladium* stage was present on pedicels and calyx lobes of the blossoms of cordons and bush trees at Wye and on the young leaves amongst the blossoms. Conidial pustules were present commonly on the one-year-old prolongations of the spurs and on the bases of one-year-old shoots. The resistance of the fruit seems to be maintained, for in both 1932 and 1933 the young pears were spotted with Scab at an early stage but never became seriously affected. CHERRY.—On 19 October the orchard at Newington (this *Journal*, No. 31, p. 15, January 1933) in which *Pholiota squarrosa* occurred, was visited. Sporophores were present near the trees already marked but no spread to neighbouring trees had occurred. *Ganoderma* (*Fomes*) *applanatum* was found at the base or anywhere on the trunks of living cherry trees. In another orchard at Wye, Kent, *Armillaria mellea* on 31 October was commonly present on cherry trees and the masses of sporophores followed the lines of the main roots. About a quarter-mile away, a new mixed orchard of cherries, plums and apples had been planted and it was found that this was in danger because the fungus was established on old stumps of trees situated in a wide hedge bordering one side of the orchard. Rhizomorphs and sporophores extended in the turf to a distance of eighteen paces from the hedge and were approaching the nearest row of fruit trees. When these orchards were again visited in March the work of grubbing large numbers of infected trees was in progress; tree stumps in the hedge of the new orchard were removed, and the turf at the edge of the orchard had been ploughed. Pieces of rhizomorph were found on the upturned furrow-slices. Brown Rot caused little damage in 1933 and the Blossom Wilt form of attack was reported only on Morello cherries. PEACH.—The Powdery Mildew (*Sphaerotheca pannosa* var. *persicae*) was received in May from indoor trees; conidiophores occurred on fruits and leaves.

GOOSEBERRY.—The disease to which attention was most called in 1933 was that known as "Cluster-Cup" (*Puccinia Pringsheimiana*). Mr. G. C. Johnson, Horticultural Superintendent for East Sussex, having noted that the disease was prevalent in 1932,

made special efforts to find the rust on its alternate host, the Sedge (*Carex* spp.), but without avail. By 7 June the disease was reported by him to be as widespread as it had been in 1932. It was particularly bad at Newick and at Dane Hill and specimens were received from East Grinstead and Nutley. Mr. Johnson stated that 30-40 per cent. of the fruit on " Leveller " bushes was infected ; often the foliage was badly spotted and in two cases aecidia had been found on the wood, at the base of spines. The first of many examples was received at Wye on 20 May from the Canterbury district and the last on 6 July from Faversham. RED CURRANT.—Aecidia of *P. Pringsheimiana* on fruits of red currant were sent in from Kent and from Sussex. Coral Spot (*Nectria cinnabarina*) caused great damage in a two-acre plantation of Laxton's Perfection at Selling, near Faversham, in the first week of June. The grower reported that the first wilting occurred when the buds started growth in spring and when the leaves were unfolding. The variety Fay's Prolific planted close by in three blocks, each of 4 acres, showed some trace of the disease but only to a very slight extent.

STRAWBERRY.—On 18 May at the request of the grower, a visit was paid to a strawberry plantation at Ruckinge, Kent, where scorching of the foliage of the Paxton variety was causing some alarm. The laminae of the outer leaves were slightly affected with *Ramularia Tulasnei* (the conidial stage of *Mycosphaerella fragariae*) in the usual " spot " form, but in addition, large areas were brown, dry and withered or sometimes the whole lamina was killed. Young and healthy green leaves were beginning to grow up in the centre of the affected plants. On holding up to the light some of the scorched leaves, it was seen that very numerous small angular spots occurred and on the lower surface of these were white masses of *Ramularia*. This very severe damage and the presence of *Ramularia* in such great quantity and not limited to the familiar " bird's-eye " form of leaf-spot, is in our experience most unusual.

ORNAMENTAL PLANTS.—On Sweet William (*Dianthus barbatus*) both Rust (*Puccinia Lychnidearum*) and Leaf Spot (*Heterosporium echinulatum*) were sent in on several occasions during the winter months. One case of Shab (*Phoma Lavandulae*) on Lavender was received from Hythe, Kent. On the leaves of Canterbury Bell (*Campanula medium*) a brown angular spotting was found to be due to a *Ramularia* with very large spores measuring $30\text{-}60\mu \times 6\text{-}8\mu$ and usually three-septate. A trouble with forced Hyacinth bulbs (var. Bismarck), received from Maidstone, was recognized by Dr. G. H. Pethybridge as of non-parasitic origin and the same as that described by the Dutch as " Spouwen ". The young flower bud (spike) becomes entirely separated from the bulb but its separation is naturally not discovered until after the surrounding leaves have opened. In the present case the grower noticed the trouble (which might well be called " Loose Bud ") about one week after the bulbs had been brought indoors on 25 November and he was sure that the inflorescence was clear of the bulb before forcing began. It is not certain whether the bud is pulled off by the tightly gripping leaves when they elongate or whether the severance is due to bursting of the stem cells after distension with water. The bulbs were French-grown and were not " prepared ". A grower at Crowborough, Sussex, sent in Tulip plants suffering from the disease known as " Shanking " and due to *Phytophthora cryptogea* which was causing great damage in a planting of 20,000 bulbs. " Blind " buds in Tulips, due to physiological causes, were also received. Root-rot of Arum Lilies caused by *Phytophthora Richardiae* was sent in from Barnham Junction, Sussex. A rust of Antirrhinums, new to this country, was described by D. E. Green in the *Gardeners' Chronicle*, Vol. 94, p. 131, 12 August 1933. There is now no doubt that the fungus is established in this area (Kent, Surrey, Sussex) and has been found also in

Hampshire, Essex and Oxfordshire. The original case, described in the above article, was at Sidcup, Kent. This rust was first recognized about 1903 in California and it spread through the U.S.A., Canada, and Bermuda but has, until now, never invaded Europe. Specimens were received at Wye on 14 August from near Faversham and subsequently from Mr. G. C. Johnson (Horticultural Superintendent for East Sussex) from various places in that county.

HOPS.—*Verticillium-Wilt.*—Two cases of this comparatively rare disease have been sent in, from two farms in the Paddock Wood district, on the variety Fuggle. In both cases the mycelium of the fungus (*Verticillium albo-atrum*) was found in the wood-vessels in the lower portion of the bine. In one case the mycelium was found to be present, in slight quantity, at 4 ft. 6 in. from the attachment of the bine to the rootstock, and to be abundant at a height of 3 ft. It was absent at 6 ft. Mycelium in considerable quantities was present in the wood-vessels in the rootstock at 2 in. below the place of attachment of the bine. *Verticillium* conidiophores developed on pieces of bine, split longitudinally, and kept moist in a glass dish.

*Cladosporium Disease.*—In our report for 1929 (this *Journal*, No. 27, p. 87 (1930)) we recorded the infestation of the cones of Fuggle hops by a species of *Cladosporium*, " producing a brown discoloration very similar to that caused by Downy Mildew ". A case occurred in August last, in a garden of Fuggles in the parish of Hawkhurst. The garden was visited, and the disease was found not to extend throughout the garden but to be confined to the first ten or twelve rows on the south side. The affected cones were mainly on low laterals within reach and were on the north side of the hill and consequently less exposed to sun. The cones exposed to full sun and near the top of the bine were healthy. The mycelium and spores of the *Cladosporium* occurred commonly on the bracts, but occasionally on the bracteoles, of the cone, and caused a brown discoloration of petals, extending in lines down the cone, which might easily be mistaken for an attack of Downy Mildew. As a matter of fact, the owner of the hop garden had so regarded the disease, and because of that was picking the crop two days earlier than he had originally intended to do.

*Small Hop Disease.*—A typical example of this disease was received in September from Bromyard, Herefordshire. In a communication, received in March from Dr. C. Blattny of Prague, this author writes, " it seems that I have described the same disease under the name ' pupenovitost ' in *Ochrana Rostlin*, VIII, Part 5, 117-28 (1928), and under the name ' Knospenfülle ' in the periodical *Gartenbauwissenschaft*, 1929 ". In the former periodical, an illustration is given, on p. 119, in which a crowded mass of buds is shown, very similar to that illustrated in our Figs. 1 and 2, in this *Journal*, No. 30, pp. 23, 24 (1932).

" *Ivy-leaf* " *Disease.*—The diseased condition of the bine referred to in our last Report (p. 16), in which the tip of the bine is thin and malformed, with the nodes " knotted ", and with the lower leaves of an abnormal shape (three-fid, and resembling an ivy leaf, with untoothed margin) and crinkled or puckered, was again met with. Specimens were sent in May from Herefordshire and the disease occurred also in the Hop Nursery at Wye.

*Diseases probably due to abnormal Weather Conditions.*—During June several cases were investigated in which the tips of the bine showed a diseased growth, being yellowish

in colour (with abnormally large stipules), and stiff and inclined to leave the strings. This condition existed in hop gardens in the parishes of Wye, Eynsford, Wickhambreaux, Paddock Wood, East Peckham, Goudhurst and Canterbury, occurring on the varieties Canterbury and Eastwell Goldings, Bramling and Fuggle. In one garden, where it was observed that the lateral shoots also on some hills were stiffened and stunted, a certain number of the worst affected hills have been marked for observation next season.

Another disease, to be ascribed almost certainly to the action of low temperature following very hot weather, occurred on a widespread scale during June, and for several weeks we were kept busy answering the very numerous enquiries by telephone and letter. This disease was characterized by a definite browning or " scorching " of the leaves at certain of the nodes—from the fifth to the eighth node from the apex. The affected leaves either withered completely and curled up or remained flat, and showed brown, " scorched ", irregular-shaped areas between the main veins. Only the variety Fuggle was affected ; other varieties growing alongside affected Fuggles remained immune. The cases observed, which were often the cause of considerable anxiety to the grower concerned, were in the following parishes :—Kent—Sittingbourne, Yalding, Faversham, Pembury, Goudhurst, Lamberhurst, Bethersden, Tonbridge, Hunton ; Surrey—Puttenham ; Hampshire—Alton, Bentley ; Worcestershire—Worcester, Callow End, Pershore, Newnham Bridge ; Herefordshire—Ledbury ; Sussex—Northiam.

Mushrooms.—Visits have been exchanged with established and intending mushroom growers and a large amount of correspondence has been carried on relative to a wide variety of subjects such as the possibility of obtaining instruction in the methods, growing mushrooms in the open field, building construction, the nature of fungi present on the casing-soil, the use of lime, substitutes for stable manure, the literature on mushroom growing, making the compost, fungi present in the beds, the suitability of buildings (e.g. disused cow-houses) and the use of chemical manures as a stimulant to the crop. Many enquiries related to the diseases of mushrooms and numerous specimens have been examined. *Mycogone perniciosa* is evidently the commonest parasitic fungus and it is of interest to note that in the opinion of an experienced grower the brown variety of mushroom is resistant or immune. It had been observed that where brown and white mushrooms were grown together on the same bed, the brown did not become attacked although the white were badly affected. The production on mushroom beds of small buttons which are soft and leathery and lacking the usual healthy colour, was a constant cause of enquiry. These small buttons never develop and remain in the dry, leathery condition or sometimes become dark-coloured and slimy with bacterial invasion. One cause is the severance of the " roots " by larvae but in the majority of cases no such damage can be found. The presence of small buttons is a feature of beds which are exhausted and they commonly occur after each " flush " of mushrooms on beds which are in full cropping. In the latter case they can be prevented by exercising greater care in the digging out of " stumps " after picking. Several examples of spotting of the upper surface of the pileus, due to *Bacterium Tolaasi*, have been received and others in which the whole pileus was slimy and the internal tissue of the mushroom invaded by bacteria. The *Verticillium* disease of mushrooms, mentioned in previous reports, reappeared after a short interval and the circumstances are of interest. The straw-covered sheds in which it had first been found were removed in 1931 and the ground, dug and treated with 2 per cent. formalin, was rested during 1932 ; a large new shed was built over the original heating pipes which were not removed, the one new shed therefore occupying the exact site. The first crop to be grown in the new shed was attacked and,

in July 1933, showed many of the white deformed mushrooms. The earth floor had not been covered with concrete as had been done in an adjoining new shed built on an infected site, but even with this precaution a trace of the *Verticillium* was present—perhaps only transported by human or insect agency from the badly infested shed with the earth floor. A paper describing the *Verticillium* disease of mushrooms is now in the press. An investigation of certain fungi, which are invaders of commercial mushroom beds, has been made and an account of this is included on p. 26.

During the past season, mushrooms were grown for the first time as a farm crop in the buildings at two of the College Farms and assistance from the Mycological Department was given. The beds were put down in the winter of 1932 and, in the absence of any heating plant and owing to very cold weather at the end of January, they remained dormant for five months and did not begin to produce until the month of April. Cropping, however, was good and continued until the end of August.

## Research Work.

The following investigations have been made :—

1. The Downy Mildew of the Hop (*Pseudoperonospora humuli*). A considerable number of advisory visits were paid to affected hop gardens and advice was given by correspondence to a large number of growers in all the hop growing counties on spraying and other methods of prevention of this disease. The attacks of Downy Mildew were severe on the bine in the early part of the season, both in the form of " basal spikes " and later, in May, as " terminal spikes ", and in certain districts in Kent, Hampshire and Worcestershire the growth of the bine was seriously damaged. The phenomenally hot, dry weather of June, July and August reduce the fungus, generally speaking, to a barren (non-sporing) condition. The majority of hop growers took no risks, however, and some three-quarters of the hop acreage was well sprayed with Bordeaux mixture, applied twice or three times. It must be pointed out that even in so hot and dry a summer as that of 1933, the disease could be found lurking in the form of partly dried up lateral spikes or minute patches of spores on the under surface of the leaves of lateral shoots high up in the " heads " of bines, and had the weather turned wet in August, some attack on the cones would almost certainly have taken place in unsprayed gardens. As it was, a perfectly healthy crop of hops was secured. A detailed account of the incidence of the disease will be published shortly. An account of its occurrence in hop gardens in 1932 has been published (8).

Experiments were again carried out in the Wye Field hop garden, in which a copper-lime powder was applied to the hills just before and during the period of the production of basal spikes. No definite effect on the occurrence of basal spikes was observed.

2. Spraying Experiments against Apple Scab.—In conjunction with the Chemical Research Department, spraying experiments have been continued, for the seventh year, in the College plantation at Wye. Similar plots of Allington and Newton Wonder have been sprayed, respectively, with home-made Bordeaux mixture and a vegetable oil-Bordeaux emulsion. The crop will be graded by hand and the results recorded in the *Jour. S.E. Agric. Coll.*

The results of the spraying experiments at Wye in 1932 have been published (7). The crop was an excellent one, and 3½ tons of Allingtons and 5 tons of Newtons were

hand-graded for Scab. The trees of Allington Pippin sprayed four times with home-made Bordeaux mixture (two applications pre-blossom, and two post-blossom) gave 6 per cent. of Scab-infected apples; sprayed similarly with mustard oil-Bordeaux emulsion, 17 per cent. of Scab-infected apples. In the three control (unsprayed) plots the percentages of Scab-infected apples were 71, 81 and 81. The trees of Newton Wonder sprayed four times with home-made Bordeaux mixture gave 11 per cent. of Scab-infected apples; sprayed similarly with mustard oil-Bordeaux emulsion, 47 per cent. of Scab-infected apples. In the three control (unsprayed) plots the percentages of Scab-affected apples were 98, 96 and 98. The biological observations made in the plantation indicated that attacks of the disease were late in the season. For this reason the extra pre-blossom spraying, given for the first time in 1932, cannot alone be credited with having brought about the improvement in health of the crop in Newton Wonder. Uncontrolled differences in the biological condition and previous Scab history of the trees in the two plots make a comparison of the fungicidal efficiencies of Bordeaux mixture and the oil-Bordeaux emulsion almost valueless. It is, however, noteworthy that the greater Scab infection in the oil-Bordeaux plot is associated with smaller amounts of copper found to be retained on the foliage.

At the request of the Ministry of Agriculture and in co-operation with them and members of the Kent County Horticultural Staff, a spraying demonstration against Apple Scab was again carried out in an orchard, consisting of Bramley's Seedling, at West Farleigh, near Maidstone. As in 1932, plots were sprayed with home-made Bordeaux mixture and with Lime-sulphur. Biological observations respecting the incidence of Scab were kept through the season. A representative portion of the crop from the sprayed trees and all the crop from the unsprayed trees were hand-graded to ascertain the amount of Scab present. An account of the results obtained will be published. The results in 1932 have been presented by Mr. W. G. Kent in an article in the *Journal of the Ministry of Agriculture*, XL, p. 420 (1933), which may be consulted for details. A satisfactory control of Apple Scab was obtained, at small cost, by four sprayings with either Lime-sulphur or Bordeaux mixture. The costs of the sprayings are given, and times required for application, both being less than is common in commercial practice.

3. PEAR SCAB (*Venturia pirina*).—In conjunction with Mr. H. Martin (Chemistry Research Department) a spraying experiment at Sandbanks Farm, Graveney, Kent, for the control of Pear Scab was arranged through the kindness of Mr. E. Vinson, who co-operated in every detail, including the provision of labour and equipment.

Randomized plots, each of fifty to seventy trees, of the varieties Louise Bonne of Jersey, Williams' Bon Chrétien, Marguérite Marillat and Doyenné du Comice, were sprayed either with Bordeaux mixture or with cottonseed oil-Bordeaux emulsion. With both of these, a comparison was made of the effects of two and of three post-blossom applications, all plots receiving one* pre-blossom spray. The trees were all upright cordons planted in 1918 on the square at approximately 5 ft. They were about 10 ft. high with a spread of 1-2 ft. The plots consisted of 1,240 trees of which 152 (composing three plots) were left unsprayed. During the season, records were made of the progress of the disease and of the effects of spraying on the trees. On 23 August the crops of Williams' and of Marguérite Marillat were graded for the amount of Scab present, but

* It had been intended to give two pre-blossom applications but the warm dry weather caused an early opening of the blossoms.

the quantity of Louise Bonne and of Comice was too small to obtain reliable results and was therefore not graded.

A very good control of Scab by both of the spray fluids was obtained on both the varieties graded. Three post-blossom applications gave better control than two. A full description of the experiment and the results obtained will be published shortly.

4. Virus Diseases of the Hop.

(*a*) *Chlorotic Disease.*—No fresh cases of this disease, at present known only on a few farms in Worcestershire, have been reported. Although the hop growers concerned have been strongly advised to grub all affected stocks, the disease still exists in some of the original localities.

A case occurred at Wye of the natural spread of the disease, one plant of a Seedling hop (Ref. No. B18) showing typical symptoms on the upper leaves of one bine (2 ft. 9 in. high) on 12 April. This plant had been kept in the greenhouse during the winter, and the aphis *Myzus persicae* had been observed to be present. As this insect is a well-known vector of virus diseases, it is possible the Chlorotic disease was transmitted by its agency from certain affected plants kept at Wye for experimental purposes.

Seed has been sown from plants of Fuggle affected with this Chlorosis and proof obtained that it can be transmitted through the seed. Details of the experiments carried out will be published shortly.

A third paper in the series has been published (2), giving the results of further grafting and budding experiments.

(*b*) *Split-Leaf Blotch.*—In previous reports we have referred to the occurrence of "Split-Leaf"—a supposedly virus disease—which causes a splitting of the lamina at a short distance from the petiole. An aggravated form of apparently the same disease has been met with, in which yellowish, "oily"-looking blotches appear, anywhere over the lamina, which are so thin that the tissue either dies and turns brown or splits apart. Such leaves may appear on the main bine or on the laterals. The most serious case was in a garden of Fuggles, near Faversham, which we visited on 3 July. Throughout the garden hills occurred which were so severely affected and weakened that the bine was only just past the bar string, whereas that of healthy hills was over the top wire. The grower was seriously alarmed at the damage being done and has marked two hundred of the worst affected hills to ascertain to what extent the disease persists from season to season. We received similar specimens in late June from Stockton, Worcestershire, and a well-known hop grower farming in Worcestershire has written to us that in his opinion "Split-Leaf" is becoming a disease of serious importance. It is attacking Goldings as well as Fuggles.

5. Invaders of Mushroom-Beds.—In February 1933, through the kindness of Mr. W. Buddin, Economic Mycologist, University of Reading, an opportunity was afforded of studying at first hand the "disease" of mushroom spawn described by Costantin (*Bull. Soc. Myc. de France*, 8, 153, 1892) and named by him "Le Chanci". Forty-one years ago it was more likely than it is to-day that the mycelium of competitive fungi could be introduced into mushroom beds by way of the spawn, and the occurrence of the fungus *Clitocybe dealbata* (mentioned by Costantin in connection with "Le Chanci") in mushroom beds on a farm in Hampshire was of particular interest from the point of view of its origin. After visiting the farm and obtaining all details from the

grower, it seemed to us most probable that the fungus had been introduced by way of the stable manure used in making the beds. With Mr. Buddin, a paper (4) was written describing this occurrence of *Clitocybe dealbata*.

Another fungus which, by its rank growth in mushroom beds, tends to exclude the mycelium of the mushroom more or less completely, is that usually known as *Xylaria vaporaria*. It forms large black resting bodies (*sclerotia*) in the casing soil but is not known to produce any spores under the ordinary conditions of mushroom culture. In the course of investigation of this fungus, when under artificial conditions it was induced to fructify, it was found not to agree in certain respects with the original descriptions of *X. vaporaria*. The fungus was obtained from mushroom beds at Southampton, Eastbourne and Wye, and in all cases showed this disagreement. Investigations will be continued to ascertain whether the differences are of varietal or specific rank.

6. FUNGICIDES.—In collaboration with the Chemical Research Department, the investigation of the fungicidal properties of vegetable oils by spray trials on the conidial stage of the Hop Powdery Mildew (*Sphaerotheca humuli*) has been completed, and an account of the results obtained has been published in the series " The Fungicidal Properties of Certain Spray Fluids " (5). An examination has been begun of the action, as direct fungicides, of various copper-containing sprays, of certain organic sulphur compounds and of substances suitable for use as spray spreaders.

7. IMMUNITY STUDIES.—The study of the resistance of New Varieties of hops to " mould " (*S. humuli*) has been continued. During 1933 several immune male hops, of hybrid origin, have been discovered and will be used in further " crossing " work.

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3. GOODWIN, W., and WARE, W. M. Mushroom Growing. *Gard. Chron.*, 92, No. 2,399, 451-2, 17 December 1932.
4. BUDDIN, W., and WARE, W. M. *Clitocybe dealbata* as an invader of mushroom beds. *Gard. Chron.*, 93, No. 2,415, 246-8, 8 April 1933.
5. MARTIN, H., and SALMON, E. S. The Fungicidal Properties of certain Spray Fluids, X. Glyceride Oils. *Jour. Agric. Sci.*, XXIII, Part 2, 228-51, April 1933.
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7. GOODWIN, W., MARTIN, H., SALMON, E. S., and WARE, W. M. The Control of Apple Scab: Allington Pippin and Newton Wonder, 1932. *Jour. S.E. Agric. Coll.*, No. 32, 95-107, July 1933.
8. SALMON, E. S., and WARE, W. M. The Downy Mildew of the Hop in 1932. *Ibid.*, 108-19, July 1933.

# HOPS

By Prof. E. S. Salmon.

The breeding of new varieties of hops and subsequent testing for resistance to disease and for their commercial value as regards yield, aroma and amount of resins have been continued. Seedlings raised in recent years from the parent plant C9*a* (see below) and from the cross Bramling × male hops raised either from the American species *Humulus americanus* or its variety *neo-mexicanus*, are showing high promise. It is now possible for the crop of individual plants to be dried separately on the experimental kiln constructed at Wye College by Mr. A. H. Burgess for his work on arsenical contamination; this has considerably expedited the work of determining the value of new seedlings as regards aroma and richness in resins—as previously a new variety had to be propagated until a sufficient number of hills could be grown at the East Malling Research Station to provide for the drying on a commercial oast of a part-pocket of hops.

The Sixteenth Report on the Trial of New Varieties of Hops, 1932, has been published (2). Among the chief features of interest are the following :—(*a*) Of the 207 Varieties (New and Commercial) tested, three New Varieties cropped at the rate of over 30 cwt. to the acre; twelve other New Varieties at 25 cwt. or over; and thirty-nine New Varieties at from one ton to 24¾ cwt. to the acre. (*b*) The number of bushels (Imperial) of green hops required to the cwt. of dried hops varied from 78 to 142. (*c*) In all the classes (Early, Midseason and Late Varieties) certain New Varieties proved on analysis to be richer in preservative qualities than any of the Commercial Varieties. (*d*) The New Variety C9*a* (a " Manitoba Seedling ") was richer in preservative qualities by 3·11 per cent. than the richest sample of American hops obtainable. There is reason to believe that in the season of 1932 C9*a* was the richest hop in the world.

One of the most promising New Varieties is OP21. This is considerably richer in preservative qualities than any hop at present grown in this country and has been found satisfactory as regards flavour when used in brewing trials. The stock at East Malling Research Station has been used for propagation purposes, and sufficient sets have been raised for the planting up this year, in Kent and in Worcestershire, of two half-acre demonstration plots on hop farms. Sets will be available for distribution in 1934 and growers who wish to purchase these should make application either to East Malling Research Station or to Wye College. In the last brewing test, carried out by Mr. J. S. Ford at Messrs. Wm. Younger & Co.'s Abbey Brewery, Edinburgh, the unanimous decision of the judges was that OP21 was perfectly satisfactory as a copper hop. A large-scale trial to test the value of the hop as a " dry hopper " was made, and the unanimous opinion of the same testers was that OP21 was a quite excellent hop as regards flavour and form. If further experiments confirm the suitability of OP21 as a dry hopper this New Variety is assured of a commercial future, as it is very rich in preservative properties.

Another outstanding hop is C9*a*. This is one of a class which are heavy croppers and whose cones possess a strong " American " aroma. Other promising members of

this class, all with a similar aroma and all possessing the high preservative properties of the best American hops are 411, R3/100, Y90, and OZ79. All such hops are suitable for blending in the copper or for " stouts ". Further information regarding C9*a* is given below (p. 33).

It is satisfactory to be able to record here that OP21*, C9*a*, 411, R3/100 and a few other New Varieties are now beginning to be grown on a commercial scale on certain farms in Kent, Sussex and Hampshire—in one case by a firm of Brewers.

Mr. A. H. Burgess reports :—

Under a grant from the Institute of Brewing the investigations on hop-drying have been continued. A report on the work carried out in 1930 and 1931 has been published (3).

With the assistance of Mr. A. J. Thomson and Mr. H. Martin, chemical analyses of 257 samples of hops and biological tests on thirty samples have been made.

Advice has been given, by correspondence and personal visits, on problems connected with cultivation, manuring and drying hops, and upon oast-house construction.

In conjunction with Dr. Goodwin experiments to determine whether spraying with Bordeaux mixture has any deleterious effect upon wirework have been continued.

In conjunction with Mr. Martin a preliminary experiment on the treatment of hop string has been made with a view to assisting the control of Downy Mildew.

A series of special lectures on Hop Growing was given to students at the College in the spring and summer terms. A lecture on Manuring Hops was given at the Hop Conference held at the College in January.

A preliminary trial has been made on the use of spent hops for mushroom growing.

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(1) SALMON, E. S. July 1933. Sixteenth Report on the Trial of New Varieties of Hops. (Ashford.)

(2) SALMON, E. S. September 1933. Report on Hop Investigations at Wye College, 1931-32. *Jour. Inst. Brewing*, XXXIX (N.S. 30), No. 9, 513-15.

(3) BURGESS, A. H. 1933. *Jour. Inst. Brewing*, XXXIX, 8.

* It is proposed to name this variety " Brewers' Favourite ". A description of this hop will appear in the next number of this *Journal*.

# HOP RESEARCH SCHEME

## Hop Experiments—Wye Field.

By A. H. Burgess.

The experiments upon time of application of quick acting nitrogenous manure and time of cessation of deep cultivation have been continued. The whole garden was treated with 6 cwt. per acre of Superphosphate (18·72% $P_2O_5$) and 2 cwt. per acre of Muriate of Potash (50·42% $K_2O$) and was limed at the rate of 1 ton per acre in late winter.

The nitrogenous manure, supplying 290 lb. of nitrogen per acre to the Early Birds and Cobbs, and 250 lb. of nitrogen per acre to the Canterbury Goldings, was applied as follows:

Early Birds and Cobbs.

| | | |
|---|---|---|
| Plots M1 | 45 lb. 10 oz. | Shoddy (41·07 cwt. per acre). |
| Plots M2 | 13 lb. 13 oz. | Sulph. Ammonia (12·43 cwt. per acre). |
| Plots M3 to M7 | 20 lb. 0 oz. | Shoddy (18·00 cwt. per acre). |
| | 7 lb. 12 oz. | Sulph. Ammonia (6·98 cwt. per acre). |

Canterbury Goldings.

| | | |
|---|---|---|
| Plots M1 | 39 lb. 5·5 oz. | Shoddy (35·42 cwt. per acre). |
| Plots M2 | 11 lb. 14·5 oz. | Sulph. Ammonia (10·72 cwt. per acre). |
| Plots M3 to M7 | 20 lb. 0 oz. | Shoddy (18·00 cwt. per acre). |
| | 5 lb. 13·75 oz. | Sulph. Ammonia (5·28 cwt. per acre). |

(Shoddy—6·36% nitrogen; Sulph. Ammonia—21·00% nitrogen.)

Downy Mildew was first noticed in the garden on 27 March; the " spikes " caused by this disease were systematically removed and counted. The times of removal and numbers found are given in the following table:

*Downy Mildew " Spikes " removed from Wye Field,* 1933.

| Early Birds. | | Cobbs. | | Goldings. | |
|---|---|---|---|---|---|
| Date. | No. | Date. | No. | Date. | No. |
| April 13th | 442 | April 13th | 190 | April 13th | 780 |
| April 17th | 264 | April 17th | 136 | April 17th | 356 |
| April 21st | 150 | April 21st | 134 | April 21st | 440 |
| April 27th | 150 | April 27th | 112 | April 27th | 593 |
| May 1st | 283 | May 1st | 56 | May 2nd | 856 |
| May 4th | 170 | May 5th | 98 | May 5th | 386 |
| May 8th | 308 | May 9th | 92 | May 10th | 1,041 |
| May 11th | 119 | May 12th | 68 | May 13th & 15th | 578 |
| May 16th | 165 | May 17th | 71 | May 18th | 308 |
| May 19th | 75 | May 22nd | 200 | May 22nd | 2,050 |
| May 24th | 786 | May 24th | 295 | May 25th | 767 |
| May 30th | 108 | May 30th | 35 | May 31st | 83 |
| June 1st | 29 | June 3rd | 22 | June 5th | 82 |
| June 6th & 7th | 42 | June 8th | 18 | June 9th | 42 |
| June 12th | 5 | June 14th | 3 | June 14th | 9 |
| June 16th | 1 | June 19th | 0 | June 19th | 0 |
| | 3,097 | | 1,530 | | 8,371 |
| " Spikes " per hill | 1·366 | | 0·675 | | 3·089 |

In 1932 the Early Birds and Cobbs were equally affected by the disease (4,750 and 4,716 " spikes " respectively), the Goldings, however, produced over three times as many " spikes " (19,280). During the present season (1933) the Goldings were again most severely attacked, producing more than twice as many " spikes " as the Early Birds and more than four times as many as the Cobbs. Spraying with Bordeaux mixture was commenced on 18 May ; it was repeated six times on the Early Birds and seven times on the Cobbs and Goldings.

Aphis were somewhat troublesome ; they were not present in large numbers but were very persistent. The hops were washed three times with Nicotine and Soap and were powdered twice with 3 per cent. nicotine powder.

The hops appeared to be free from mould but were sulphured when the hops were in burr as a precautionary measure.

The crop was picked in good condition and free from disease.

The weight of green hops per plot and other details have been recorded.

The crop produced was :

| | |
|---|---|
| Early Birds .. .. .. .. | 23·3 cwt. per acre. |
| Cobbs .. .. .. .. .. | 27·3 cwt. per acre. |
| Canterbury Goldings .. .. .. | 26·6 cwt. per acre. |

The following are the total weights of green hops obtained from the various cultivation and manurial treatments in 1932 :

*Cultivations.*

| Early Birds. | | Cobbs. | | Goldings. | |
|---|---|---|---|---|---|
| Cultivation. | Crop. (lb. green hops.) | Cultivation. | Crop. (lb. green hops.) | Cultivation. | Crop. (lb. green hops.) |
| C6 | 1595·8 | C3 | 1781·4 | C6 | 1471·1 |
| C2 | 1587·5 | C6 | 1736·4 | C2 | 1441·3 |
| C3 | 1559·8 | C4 | 1736·2 | C1 | 1398·4 |
| C4 | 1555·9 | C2 | 1728·6 | C5 | 1391·6 |
| C5 | 1524·5 | C5 | 1711·2 | C4 | 1365·5 |
| C1 | 1456·1 | C1 | 1676·5 | C3 | 1318·6 |

*Manuring.*

| Early Birds. | | Cobbs. | | Goldings. | |
|---|---|---|---|---|---|
| Manuring. | Crop. (lb. green hops.) | Manuring. | Crop. (lb. green hops.) | Manuring. | Crop. (lb. green hops.) |
| M3 | 1401·4 | M6 | 1534·4 | M7 | 1235·2 |
| M6 | 1346·5 | M3 | 1516·4 | M4 | 1228·7 |
| M4 | 1323·5 | M4 | 1499·1 | M6 | 1197·7 |
| M1 | 1319·2 | M7 | 1490·1 | M3 | 1188·4 |
| M2 | 1308·7 | M5 | 1463·7 | M2 | 1188·0 |
| M7 | 1293·6 | M2 | 1441·0 | M5 | 1183·5 |
| M5 | 1286·7 | M1 | 1425·6 | M1 | 1165·2 |

CULTIVATION EXPERIMENTS.

C1 = No deep cultivation.
C2 = Deep cultivation discontinued as soon as possible after spring ploughing.
C3 = Deep cultivation discontinued when bines reach belt.
C4 = Deep cultivation discontinued when bines reach top wire.
C5 = Deep cultivation discontinued when hops are in the " pin " stage.
C6 = Deep cultivation discontinued when bines reach top wire. Ploughed in autumn.

MANURING EXPERIMENTS.

M1 = No quick acting nitrogenous manure.
M2 = All nitrogenous manure quick acting. Times of application A, B, C. (No organic manure.)
M3 = Quick acting nitrogenous manure in two applications, A, C.
M4 = Quick acting nitrogenous manure in three applications, A, B, C.
M5 = Quick acting nitrogenous manure in three applications, A, B, D.
M6 = Quick acting nitrogenous manure in three applications, A, C, D.
M7 = Quick acting nitrogenous manure in four applications, A, B, C, D.

Times of application :

A = Commencement of growth.
B = When bine reaches belt.
C = When bine reaches top wire.
D = " Pin " stage.

Plots M1 and M3 to M7 receive organic nitrogenous manure in the winter. All plots receive equal total amounts of nitrogen, phosphate and potash.

Autumn ploughing (C6) appears to have been slightly beneficial in the 1931-2 season ; statistical examination, however, shows that neither this nor any of the other crop differences can be attributed to differences in cultivation or manurial treatment.

A series of seven samples—representing the seven manurial treatments—was taken from each of the three varieties ; these were judged by a firm of hop merchants who, as in previous years, were unable to distinguish any difference between the samples in each series. All were of good quality.

MISCELLANEOUS.

The question of the supply of special Copper Sulphate for the preparation of Bordeaux mixture for spraying hops has been discussed with the manufacturers.

Information has been supplied to producers of coal, coke and oil with regard to fuel for hop-drying.

A pamphlet with reference to precautions to be taken when drying hops over open fires has been circulated to all hop-growers through the agency of the Hops Marketing Board.

The oast-house at Coldharbour has been successfully employed for drying grass and pyrethrum.

The small laboratory kiln has been used for drying crops of hops from single hills of Professor Salmon's new varieties.

Prof. E. S. Salmon reports :

As mentioned in the last Report, pockets or part-pockets of the 1932 crop from the plots of the New Varieties C9*a*, 411, R3/100, W107, M35, M45, ON78, Z62 and X35 were sold to Messrs. Wm. Younger & Co. for brewing trials at the Abbey Brewery, Edinburgh. A Report on these trials, by Mr. J. S. Ford, has been published in the *Journal of the Institute of Brewing*, XXXIX, 516 (1933), and may be consulted for a detailed account. It may be pointed out here that the unanimous decision of eight tasters was that Z62 and M45 were the only two of the varieties suitable for Pale Ale production. Z62 was not considered a dry hop, but M45 was quite satisfactory. There was a difference of opinion as regards X35 ; and it is stated that possibly this hop used in smaller amounts might prove useful both as a copper and dry hop. Of C9*a* it is remarked : " As it is the mildest of the Manitoba varieties and has the highest antiseptic value, its further cultivation seems desirable." In reply to a letter, Mr. J. S. Ford informed me : " As regards your query *re* C9*a*, I have never come across, in my experience of PV (preservative value) dating back twenty-two years, any hop equalling it in antiseptic value."

From the analysis made at Wye College of the richest foreign hops available, it would appear reasonable to believe that C9*a*, as grown at Wye and East Malling in 1932, represented the richest hop in the world. As recorded in the last Report in this *Journal*, (p. 27), C9*a* has been used with success in dry hopping beer (in tank previous to filtration and bottling). It is satisfactory to be able to record that applications for sets of C9*a* have been received from both hop growers and brewers.

In 1933 pockets, or part-pockets, were obtained from plots of the following New Varieties: C9*a**, 411, Z62, R3/100, ON78, OF27, M35 and X35. The majority of these will again be purchased by Messrs. Wm. Younger & Co., who have kindly promised to continue the brewing trials.

The new " One-Acre " garden, of which twenty-seven rows have been planted with sets of some of the most promising New Varieties and twenty-two rows with Seedlings, cropped satisfactorily, and four pockets of hops were obtained. Among the New Varieties planted are OP21 and OV7, for the purpose of familiarizing visiting growers with these new hops and also for the propagation of sets.

Sets of OF27, a seedling of German parentage, which is rich in preservative properties, have been raised for planting in Wye Field. OF27 is, unlike many of the New Varieties, not a " carrier " of mosaic disease.

* It is proposed to name this variety " Brewers' Gold ". A description of this hop will appear in a forthcoming number of this *Journal*.

# DEPARTMENT OF ADVISORY CHEMISTRY

By W. Goodwin.

Advisory Work.

The enquiries dealt with in the course of the past year have again had special reference to the manuring and liming of soils on the one hand, and the chemical aspect of spraying fruit and hops on the other. Most of the enquiries in connection with soils and manures have come directly or indirectly through the medium of the County Agricultural and Horticultural staffs.

The failure or abnormality of crops is a subject upon which in some cases—as when bad drainage or lack of lime or other plant nutrient is the cause—it is not difficult to afford help, but there are other cases in which something more than a laboratory examination is required. A case which falls in the latter category occurred on a farm in Romney Marsh where a crop of potatoes which had been harvested in apparently excellent condition was found to contain a large percentage of tubers which blackened on cooking. Potatoes grown from the same seed on a neighbouring farm were normal. The soils of each farm were examined and analysed without anything being found to account for the difference. The Assistant County Organizer—Mr. S. J. Travers—was able, however, to arrange a small field trial on the same farm during the past season, which had as its object the study of the effect of dressings of potash and manganese upon the quality of the same variety of potatoes as was grown last year.

The soils of hop gardens at Yalding, Hunton and Goudhurst have been examined in connection with manurial problems and in two other cases because of crop failure. Special attention has been given to drainage on the one hand and the supplies of potash and lime on the other ; experience has shown that each of these factors is of importance.

The enquiries regarding the need of lime have increased, particularly from those who were breaking up ground for a garden or small holding. Also the enquiries from growers of bulbs and flowers ; here advice as to general manuring was also sought.

Enquiries relative to the improvement of the turf or eradication of weeds were received from two bowling greens, a golf course, and a cricket ground ; recommendations as to manuring and treatment were made. A visit to a bowling green where the treatment advised last year had been carried out showed that weeds had been markedly reduced and the general state of the turf had improved.

The number of enquiries relative to artificial manures has been small, such questions being generally dealt with by the County Agricultural staffs. Advice as to the best means of utilizing poultry manure was given in three cases and one sample of dry poultry manure was sent in. It was found to be unsatisfactory and to contain nearly 80 per cent. of sand.

A few waste products such as tannery refuse have been received and their value determined.

### Investigational Work.

An unexplained disease of culinary peas—to which the name " Marsh Spot " has been given—has been prevalent in some years in the crops grown in various districts in Kent and elsewhere. At the request of the Ministry of Agriculture, and with its financial support, an investigation of the occurrence of the disease was undertaken by the College in collaboration with Mr. S. J. Travers of the Kent County Agricultural Staff.

The soils of the fields upon which the different lots of peas under observation were grown were examined *in situ* by Mr. Furneaux. About eighty samples of soil were taken in the course of this examination and the potash content estimated ; the suggestion having been made that the disease is influenced by the amount of available potash at the disposal of the crop. Samples of peas have been taken from each crop and these after examination may show whether there is a connection between the soil, or its potash content, and the disease.

A severe case of chlorosis of pear trees—resulting in some instances in the death of the trees—has been under observation for the past two years at East Sutton. The application of potash having been made in the past without result, a detailed examination was made of the soil and subsoil, three pits being dug in different parts of the plantation. It was found that the subsoil was of Atherfield Clay and at its junction with the overlying Hythe Beds material there was waterlogging. The water was found to be saturated with lime and as much of it apparently came from a stream running along the top of the plantation the owner was advised to pipe this stream and to apply liberal dressings of sulphate of ammonia around the trees. When the plantation was visited this autumn some of the trees appeared to have improved in respect of the colour of the foliage. The treatment is being continued.

A small-scale experiment—now in its second year—was designed to show whether spraying with Bordeaux mixture for the control of the Hop Downy Mildew disease has any marked effect upon the wirework of the garden. Fears have been expressed by a number of hop growers that the copper-containing spray will lead to a much more rapid corrosion of the wire than used to be normal.

In collaboration with Mr. A. H. Burgess of the Hop Research Department a number of lengths of galvanized iron wire of various thicknesses and ages were dipped into Bordeaux mixture at times corresponding with those of the usual sprayings. The wires after drying were placed in the open over receivers so that the rainwater was collected. At the end of the season the water was evaporated down to a small bulk and the amounts of iron and zinc present in each lot were determined.

It was found that in the water from the dipped wires (undipped similar wires were used as controls) there was, with one exception, less iron and zinc than from the untreated wires, thus indicating that the Bordeaux mixture had not had any effect upon the normal rate of corrosion of galvanized wire.

The various samples of wire were left out of doors during the past winter and were again treated with Bordeaux mixture during the season just concluded. The rainwater was collected and the analyses are now being made.

### Spraying Trials.

The spraying trials against Apple Scab in the College plantation have been continued on the lines of last year, save that in the preparation of " oil-Bordeaux " the expressed oil of mustard which was previously used was replaced by cotton-seed oil.

As in the past, the apples will be graded according to the amount of Scab which they show, counted and weighed. The results of last year's experiment were published in the *Journal of the South-Eastern Agricultural College*, No. 32.

The spraying demonstration on the control of Apple Scab—arranged by the County Adviser in Commercial Fruit Growing with the aid of a grant from the Ministry of Agriculture—was continued at Court Lodge Farm, West Farleigh. During the winter the trees were systematically sprayed with tar-oil washes for the control of insect pests. The Scab sprays were again lime-sulphur and Bordeaux mixture, equal blocks of trees being sprayed with each of these fungicides.

Owing to the early ripening of the fruit it was possible to harvest the crops, and grade and count the apples before the end of September. An account of the results of last year's spraying is given in an article by Mr. W. G. Kent published in the *Journal of the Ministry of Agriculture*, August 1933.

The spraying of the orchard at Flishinghurst, Cranbrook, referred to last year, was again supervised, this year more attention being paid to the application of the spray. The control of Apple Scab was excellent, the owner reporting that " I have 95 per cent. apples absolutely clear from Scab, I am almost tempted to say 99 per cent." Probably owing to the difference in weather conditions there was slightly more russeting than last year but nothing of commercial importance.

On another farm at Cranbrook the preparation of Bordeaux mixture and the method of spraying were demonstrated. The crop when seen just before harvest was good, the apples (Bramley's Seedling) were remarkably free of Scab and showed no spray injury.

FRUIT SOILS SURVEY.

This survey ended officially on 30 September 1932, by which time the High Weald area had been largely covered. It has been possible to retain Mr. Furneaux' services, thanks to grants from the Ministry of Agriculture and the College, and he has been able, in collaboration with Mr. Bagenal of the East Malling Research Station, to prepare for publication the report upon the Lower Greensand area (surveyed by Mr. Gethin Jones). This report is to be published at an early date as one of the Ministry of Agriculture's bulletins. Mr. Furneaux, also in collaboration with Mr. Bagenal, has been completing the account of the soils and fruit of the High Weald ; this report will be presented to the Fruit Soils Survey Committee very shortly.

Arising mainly out of the past work of the survey there has been a large demand for Mr. Furneaux' services, and his knowledge of the soils of Kent has been called upon where advice regarding fruit soils has been sought. A considerable number of farms have been visited, often together with the County Adviser in Commercial Fruit Growing, to advise upon the suitability of soils for the planting of fruit or to investigate cases of failure thought to be due to soil conditions.

In connection with the disease of peas, known as " Marsh Spot " (to which reference has already been made), Mr. Furneaux has examined all the soils upon which the peas (116 samples) have been grown. He has also visited the crops during growth and has assisted in the harvesting and preparation of representative samples.

In the course of the survey of the soils of the High Weald, samples have been taken from the soils of the chief soil series and the potash determined in them by the *Aspergillus* method. This method continues to prove itself valuable as a means of ascertaining the amount of available potash present in the soil, and as the past manurial history of many of the fruit soils was available the reliability of the method has been checked. In view of the importance of potash in fruit growing the information which has been obtained is likely to be of considerable value in future advisory work.

The results of the examination of the soils of the High Weald for potash showed that in a large proportion of cases there is reason to think that the application of potash would have considerable benefit upon the development of the trees and upon the size and quality of the fruit.

GENERAL.

A lecture on the Nature and Uses of Spray Materials was given at the Annual Meeting of the Goudhurst Branch of the National Farmers' Union and a similar lecture to the Dartford Branch of the same organization.

The lectures to College students have been as in past years, one course on the Chemistry of Spray Materials and the other on the Principles of Animal Nutrition.

The Conference of Advisory Chemists, which was held at Cambridge in July, was attended.

# THE CHEMISTRY OF INSECTICIDES AND FUNGICIDES

By H. Martin.

## 1. The Analysis of Spray Materials.

Sixty-two samples of spray materials have been submitted for analysis during the past year. The majority were of proprietary products for many of which special methods of analysis had to be devised. Of twenty-six samples of winter wash materials examined, two were found unsatisfactory. In one so-called "standard" tar-oil wash, the oil present was found to contain over 40 per cent. of petroleum oil. The grower intended to use this wash for the control of aphis and psylla on apples and it was condemned because it would yield, at the recommended dilution, a spray containing only one-half the amount of tar-oil found, in previous experience, to be the most efficient for this purpose, for the petroleum oils are non-toxic to the eggs of these insects. In another case a strained anthracene oil was found not up to specification and the inferior material was returned to the tar distiller.

## 2. The Ovicidal Properties of Oil Sprays.

An account of the work carried out in 1932 on the ovicidal action of hydrocarbon and glyceride oils, in collaboration with the Entomological Department, has been published in the College *Journal* (Publication 6). Confirmation was obtained of the results of previous work on the relative merits of tar, vegetable and petroleum oils as ovicides for the control of the capsid *Lygus pabulinus* and a comparison was made of the ovicidal actions of eighteen high-boiling petroleum oils of different bases and characteristics. Although a tendency was shown for oils of high viscosity to be less ovicidal, no significant correlation was found between the ovicidal efficiency and the degree of refinement or physical characters of the oils. This work has been repeated and extended during the 1933 season, and an examination has been begun of the reasons for the differences in ovicidal activity between hydrocarbon oils of tar and petroleum origin.

The field trials in 1932 were concerned with the suitability of the two-solution oleic acid and the Bordeaux mixture methods of emulsification for the home preparation of oil washes. No difficulty likely to prove serious in the hands of the grower was met in the preparation of washes by either method and, in 1933, the methods were employed in demonstration work. At one centre, the grower's workmen prepared and applied 1,000 gallons of a mixed tar-petroleum wash and, at a second centre, the constituents of the wash were bought, mixed and applied by the grower to thirteen acres of currants after a single demonstration of the method of mixing. In field trials in 1931 and 1932, certain washes prepared by the oleic acid method gave an excellent control of *L. pabulinus* on black and red currants. The cheapest of these washes, containing a mixture of strained anthracene oil and a semi-refined spindle oil, was again successfully used in 1933. The results of field trials on the control of apple capsid were less satisfactory owing to the liability of the washes to cause bud damage. During the past winter, spray trials have been made with the object of removing this danger, but erratic results were again obtained.

3. THE DISCOVERY OF NEW FUNGICIDES FOR THE CONTROL OF POWDERY MILDEWS.

The investigation of the fungicidal action of glyceride oils, carried out in collaboration with the Mycological Department, has been completed and the results published (Publication 3). The fungicidal property was shown to be associated with the glyceride structure and to be influenced markedly by the type of emulsification used for the preparation of the spray. The Bordeaux mixture method was found suitable for the field preparation of sprays containing vegetable oils and field trials on hop were carried out on the College gardens and through the courtesy of Messrs. Whitbread & Co. of Beltring and Mr. T. Neame of Faversham.

In the 1933 season an investigation was made of the fungicidal action of various copper-containing sprays on the Hop Powdery Mildew and preliminary results have indicated that, in the presence of suitable spreaders, sprays which have been used experimentally as protective fungicides against downy mildews may also control the powdery mildews. Preliminary work was also made on the fungicidal properties of certain organic sulphur compounds produced commercially as rubber accelerators and of the effect of these derivatives on the fungicidal action of sulphur.

4. THE IMPROVEMENT OF PROTECTIVE FUNGICIDES.

A serious difficulty in the practical application of Bordeaux mixture and other protective fungicides arises because the most efficient fungicidal action and the minimum of spray damage are obtained by the careful application of the spray in amounts just insufficient to produce a drip from the foliage. To obtain this result, the time taken to spray is longer and the labour involved and wear on the spraying machinery are heavier than in the application of washes of which large amounts may be applied with safety. Indeed, for the application of Bordeaux mixture by means of a hop washer, mechanical modification is necessary for the successful spraying of hops. The derivation of protective fungicides which may be applied in heavy amounts without causing spray damage or a reduction of fungicidal efficiency would not only lessen spraying time, labour and wear on machinery, but would permit the incorporation of a contact insecticide and enable, in cases where the combined spray is required, a reduction in the number of applications.

Experiments on the modification of Bordeaux mixture to permit its application as a wash have been in progress since 1931 and a general account of this work has been published (Publication 4). These experiments were concerned with the efficiency of the modified Bordeaux mixtures, firstly, as protective fungicides and, secondly, as carriers for insecticides. A full account of the latter work, which was carried out in co-operation with the Entomological Department, and details of the examination of the new insecticides referred to in last year's Report have been published (Publication 2). During the 1933 season these lines of investigation were extended to a wider range of insects and a number of new spreaders and insecticides. Included in the latter were a number of products the manufacture of which has been protected by patent by Imperial Chemical Industries, Ltd., through whose financial help it became possible to obtain entomological assistance.

The behaviour of the modified Bordeaux mixtures as fungicides has been examined by apple and pear scab trials in collaboration with the Mycological Department. The results of trials in the College plantation in 1932 were published in collaboration with

Dr. Goodwin (Publication 7) and the results suggested that when a crude expressed oil of mustard was used for the preparation of the oil-Bordeaux wash, this wash was inferior to ordinary Bordeaux mixture in the control of Apple Scab. The trial has therefore been repeated this year with a more highly refined oil and, through the kindness of Mr. E. Vinson of Faversham, spray trials for the comparison of oil-Bordeaux and ordinary Bordeaux on Pear Scab became possible. The potato, a convenient test-plant for field work, was also employed for the comparison of the fungicidal efficiency of various protective fungicide-contact insecticide combinations and, in collaboration with Mr. M. D. Austin, an account has been published (Publication 5).

The writer was invited to attend the Conference of Advisory Entomologists and Advisory Mycologists held at Bristol and to contribute to the discussion on Combined Insecticides-fungicides.

5. SPREADERS.

The examination of the possibilities of utilizing certain by-products from the refinement of petroleum oils as spray spreaders has been completed and the results submitted for publication. Methods were evolved for the isolation, analysis and classification of the active ingredients of fifteen samples of such by-products. In addition to this chemical investigation the products were submitted to small-scale spray trials with the assistance of the Entomological Department.

A number of proprietary wetting agents at present used in the textile and dyeing trades have also been examined for their suitability as spray spreaders. One such product, " Sulphonated Lorol ", has been found of great promise and it has the additional advantage that, although its manufacture is protected by patent, its composition is declared and analytical methods are available for its standardization.

6. GENERAL.

In collaboration with the Hop Research Department, a preliminary investigation was made of the treatment of hop string for the protection of the growing bine against Hop Downy Mildew.

An exhibit, conjoint with that of the Entomological Department, illustrating the relationships between composition and ovicidal properties of winter washes, was prepared for the Kent County Show at Maidstone.

## PUBLICATIONS.

(1) MARTIN, H. 1932. The Present Uses and Future Development of Spray Spreaders. *Hort. Educ. Assoc. Year Book*, I, 76-84.

(2) AUSTIN, M. D., JARY, S. G., and MARTIN, H. 1932. Some New Insecticides and possible Insecticide-Fungicide Combinations. *Hort. Educ. Assoc. Year Book*, I, 85-92.

(3) MARTIN, H., and SALMON, E. S. 1933. The Fungicidal Properties of Certain Spray Fluids. X. Glyceride Oils. *Jour. Agric. Sci.*, XXIII, 228-51.

(4) MARTIN, H. 1933. Studies upon the Copper Fungicides. II. Some Modifications of Bordeaux mixture designed to overcome Practical Difficulties in its Application. *Ann. Appl. Biol.*, XX, 342-63.

(5) AUSTIN, M. D., and MARTIN, H. 1933. The Incorporation of Contact Insecticides with Protective Fungicides. Potato Field Trials, 1930-2. *Jour. S.E. Agric. Coll.*, No. 32, 49-58.

(6) AUSTIN, M. D., JARY, S. G., and MARTIN, H. 1933. Studies on the Ovicidal Action of Winter Washes, 1932 Trials. *Jour. S.E. Agric. Coll.*, No. 32, 63-83.

(7) GOODWIN, W., MARTIN, H., SALMON, E. S., and WARE, W. M. 1933. The Control of Apple Scab: Allington Pippin and Newton Wonder, 1932. *Jour. S.E. Agric. Coll.*, No. 32, 95-107.

# DEPARTMENT OF ECONOMICS

By JAMES WYLLIE.

INVESTIGATION INTO FARMING COSTS OF PRODUCTION AND FINANCIAL RESULTS.

This investigation has proceeded on the same lines as in previous years and two more reports have now been published.

Report No. XV deals with the cost of *Horse Labour* over the five years 1926/7 to 1930/1 and is a continuation of Report No. III (1927). In the latter half of this period, during which conditions were not widely dissimilar from what they are to-day, the total cost of keeping a farm horse for a year was, on the average, about £30, of which £19 was for feeding, £4 for depreciation and £7 for shoeing, depreciation and upkeep of harness and stable equipment, veterinary and sundry expenses (but *not* including stable-time). The average cost per horse per week was about 11s. 6d. and the average number of hours actually worked per horse per week was about 30, thus giving an average cost per working hour of about 4⅝d. It is pointed out that this is one of the three basic figures required for the calculation of operation costs (ploughing, drilling, mowing, etc.), the other two being the cost per hour of the horseman and the number of hours taken per acre for the different operations. It was found that on the average each farm horse consumed the produce of between four and five acres of land each year, viz. about 30 cwt. of corn (chiefly oats), about 40 cwt. of hay and fodder and about one acre of grass.

It is emphasized that comparisons between different farms as regards the economy of horse labour must be very cautiously made, partly because of the widely varying conditions under which horses must be used and partly because of the difficulty of finding any single standard which can be relied on as a measure of the efficiency with which they are used. For example, a low cost per horse hour may be due to slack horsemen and slow moving teams, i.e. to inefficiency, while a high cost per hour may, in fact, be an indication of efficient management. Hence, a better measure of comparative efficiency is the cost per acre of horse labour, i.e. the cost per horse hour multiplied by the number of hours taken per acre.

There is ample evidence that where the horses are fed according to the amount of work they have to do, the cost per working hour does not depend so largely upon the regularity of employment as it is commonly thought to do, and an example is given to show that the efficiency of horse labour need not be greatly impaired by the use of tractors and by reducing the acreage of arable land. Another example is given to show the economies in horse labour that resulted from a complete change in the management.

Report No. XVI is the third of the series on the financial results on the College Farms and deals with the 1927 to 1932 *Arable Land Crops*. (Report No. XVIII, giving the general financial results from the farms as a whole for the six years 1926/7 to 1931/2, has now also been published.) As regards corn (wheat, barley and oats) the most striking result is that in the three years 1930 to 1932, 350 acres left an average profit of only 8s. 3d. per acre, compared with £6 8s. 2d. per acre from 371 acres in the three previous years 1927 to 1929. This decrease in profits was due to a combination

of poor yields and reduced selling prices, and would have been still greater but for a marked reduction in the production costs per acre. On the average, potatoes made a poor showing, the average cost of production per ton of ware (and seed size) being very nearly £5 per ton. In 1932, about 41 acres of rotation wild white clover seed were harvested at a net cost of 9d. per lb., a profit of £5 per acre being obtained. On the average of the six years, mangels cost 14s. 5d. per ton, seeds and clover hay 66s. 10d. per ton and rotation pastures 42s. 6d. per acre. This report provides still more evidence of the close connection between high yields and satisfactory profits, but it also emphasizes the point that high yields depend to a very large extent upon factors over which the management on any particular farm has little or no control. Thus, the average yield of wheat per acre during 1927 to 1929 was 27·3 cwt. compared with only 17·4 cwt. during 1930 to 1932, of barley 29·4 cwt. compared with only 20·8 cwt. and of oats 30·3 cwt. as against only 23·4 cwt.; and these decreases in yields must be attributed almost entirely to less favourable weather conditions during the growing and harvesting seasons.

This investigation has now been proceeding for ten years and the published results have been the subject of much favourable comment. This opportunity may be taken to reply to two criticisms, expressed or implied, which have been passed on it. First, it is said, quite correctly, that it is almost entirely concerned with raising the standard of efficiency in agricultural *production* and that under present conditions it is far more important to improve the marketing of agricultural produce. What does not seem to be sufficiently realized is that the success of the marketing schemes which are in, or about to come into, operation depends to a large extent upon very considerable improvements being made in production. It may be an improvement in quality (using that term in its very widest sense), or in the regularity of supplies, or in the balance of production between this commodity and that, that is wanted, but any such improvement raises very important *production* problems. Further, one very definite object of improved marketing is to standardize selling prices, not only from month to month but also as between one producer and another. On the other hand, nothing is more striking in the results of this investigation than the enormous variations in the production costs on different farms of almost every single commodity. Hence, the more prices can be standardized, the greater will be the need for high cost producers to reduce their costs and this also is a *production* problem.

Second, it is said that this method of investigation can deal with only a very small number of farms and that the results are applicable only to the farms actually co-operating in it. One might as well urge that the bio-chemist who carries out experiments on himself will obtain results which are applicable only to himself, or that the results of an experiment are applicable only to the particular field or section of a field on which it is carried out. One important object in this investigation is to establish general principles in economic production and this can be done just as well with ten as with a hundred cases; indeed, it is very doubtful whether the necessarily superficial study associated with large numbers of cases is nearly as useful in establishing fundamental principles in production as the much more detailed study which can be made of a small number. For example, the results obtained from the College Farms during the six years 1927 to 1932 (see Report No. XVI) are *by themselves* amply sufficient to demonstrate the overwhelming importance of *yield per acre* in the economy of crop production, while the results given in Report No. X clearly demonstrate that in the sheep folding system the cost of the folding crops is not the only important factor in determining the success or failure of this enterprise. (On most of the farms the sheep

would have lost money even if they had got the folding crops for nothing.) Production problems are generally highly complex and it would be indeed strange if they could be completely studied, let alone solved, by any superficial method of investigation.

### Food Recording Scheme for Dairy Cows.

This scheme has been extended for a fourth year, partly because the co-operating farmers were extremely anxious that it should be continued and partly because a somewhat similar scheme has now been introduced into several other provinces and it was thought that interesting comparative results might be obtained from different areas. Report No. XVII—*Food Recording and Cheaper Milk Production*—breaks new ground and is in the nature of a running commentary on the results obtained from this scheme during the three years 1930/1 to 1932/3. In this report, no attempt has been made to give in tabular form the detailed results obtained from each farm, but rather the results have been used to illustrate some of the essential principles in economic milk production. " There can be no doubt that the factor which is most immediately under the farmer's influence is the *quantity* of foods that he feeds to his cows, and it is reasonable to expect that the *control* over quantity which food records render possible will, to a very large degree, make for *economy* in their use." This expectation has been fully realized and it would certainly make for cheaper milk production if just a little of the emphasis that is laid upon ever higher milk yields, balanced rations, the use of minerals and so on, were to be transferred to *control over foodstuffs*.

### Food Recording Scheme for Pigs.

The department has been closely associated with the formation of the Kent Pig Recording Society, the chief object of which, for the time being at least, is to grade up the prolificacy and milking capacity of the sow; but just as milk recording, by itself, does not tell nearly the whole story about economic milk production, so pig recording, by itself, can never solve all the problems of the pig breeder and feeder. *Over*-emphasis upon the yielding capacity of cows and of hens has already given rise to more than one unsolved problem and *over*-emphasis upon large litters would no doubt have the same result. It seemed desirable, therefore, that an attempt should be made to obtain some reliable data upon the kinds, quantities and cost of the foodstuffs consumed in the breeding and feeding of pigs on different farms, and this is being done through a food recording scheme for pigs which is organized on similar lines to the one above-mentioned for cows. The scheme came into operation in May 1933, and for the first year at least it will be regarded as purely experimental and is restricted to about eighteen farms in Kent, Surrey and West Sussex.

### Strawberry Investigation.

This investigation has been continued for a second year and sufficient information has now been obtained on the cost side to provide a foundation for the calculation of probable net returns with different yields per acre and different selling prices.

### Canning Peas Investigation.

During the past summer, information regarding the production costs of, and gross returns from, canning peas has been obtained from twenty-six growers in Kent, and it is hoped to continue this enquiry for another season at least. The most striking feature

of the returns for 1933 has been the extraordinary variation in the yield per acre, from only a few hundredweights up to nearly 40 cwt. per acre.

LECTURES.

As in previous years, a course of lectures on agricultural economics was given to all Degree, Diploma and Certificate students and a special course on Research Work in Farm Economics was given to final year Diploma students. The total number of lectures to College students during session 1932/3 was 128. Lectures to farmers were given at Tenterden, Egerton, Hawkinge, Rye and High Halden and to glasshouse growers at Worthing.

STAFF.

No change has been made during 1932/3.

PUBLICATIONS.

The following reports, etc., have been published during the year :—

WYLLIE, J. October 1932. Investigation into Farming Costs of Production and Financial Results. Report No. XV—The Cost of Horse Labour, 1926/7 to 1930/1 (pp. 65-95). [Wye : S.E.A.C.]

WYLLIE, J., and HEWISON, N. V. August 1933. Financial Results on the College Farms. Report No. XVI—Arable Land Crops, 1927 to 1932 (pp. 74-121). [Wye : S.E.A.C.]

KNOX, M. ALLAN. September 1933. Report No. XVII—Food Recording and Cheaper Milk Production (a Report on Three Years' Results from a Food Recording Scheme for Dairy Cows) (pp. 1-39). [Wye : S.E.A.C.]

WYLLIE, J. July 1933. "Horticultural Accounts." *Jour. S.E. Agric. Coll.* (pp. 24-37).

WYLLIE, J. "The Calculation of the Annual Cost of Farm Machinery and Implements." *Jour. Royal Agric. Soc. of England*, Vol. 93, 1932 (pp. 45-67).

WYLLIE, J. "An Adventure in Certified Milk Production." *Jour. Brit. Dairy Farmers' Assoc.*, Vol. 45, 1933 (pp. 30-46).

WYLLIE, J. "Efficiency in the Cowsheds." *Ann. Rept. of the Central Council of Milk Recording Societies*, 1932 (pp. 35-7).

WYLLIE, J. "Cost Accounting", in a symposium on Recent Progress in Agricultural Economics. *Agricultural Progress*, Vol. X, 1933 (pp. 21-4). [Heffer & Sons, Cambridge.]

KNOX, M. ALLAN. July 1933. "Cost per Unit as a Measure of Efficiency." *Jour. S.E. Agric. Coll.* (pp. 38-41). [Wye: S.E.A.C.]

# VETERINARY DEPARTMENT

By A. D. McEwen.

"Struck."

Owing to the comparative absence of the disease in 1933 field vaccination experiments again gave negative results.

Owing to the dry summer it is probable that the winter keep on the Romney Marsh may not be so abundant as usual and that in the coming season "struck" may be more prevalent, therefore it is hoped to make another and extensive field trial of the protection conferred by vaccination. Should no results be obtained therefrom because of the rareness of disease the question of "struck" will not be reopened unless fresh evidence of the necessity to do so arises.

Gas Gangrene.

Supplies of "gas gangrene" serum made at the laboratory were distributed to a number of farmers. The value of the serum as a prophylactic against "gas gangrene" in the parturient ewe was favourably reported on and it is intended to test the serum again next spring. It is possible that the inoculation of serum may become an accepted method of preventing the disease in ewes.

Johne's Disease.

Last year Johne's disease was reported as causing heavy loss in a flock of sheep. The infected and other flocks where the disease was unknown were tested with johnin but reliance could not be placed on the results. Accordingly an attempt was made to control the disease by removing all unthrifty sheep from the flock and by improving their water supply and during the winter the flock appeared in good condition. Some time after lambing, however, one or two cases of the disease occurred, but the incidence this year was very materially reduced.

It is important to observe that at post mortem examination many affected sheep failed to show any appreciable thickening or corregation of the mucosa of the intestine, which changes are regarded as so characteristic of the disease in bovines. Smears made from the intestinal mucosa, however, generally showed very large numbers of acid fast bacilli but in exceptional instances no bacilli were found. Histological preparations of the intestine, however, showed nests or collections of epitheliod cells in the mucosa which were characteristic for all cases examined and may be regarded as diagnostic.

Numerous attempts were made to cultivate the bacilli which were abundantly present in the intestine and the associated lymphatic glands, but in no instance was growth obtained although the medium used was similar to that upon which bovine Johne's bacilli are readily cultivated. Various modifications of the medium were also

tried but without success. There is, therefore, reason to suspect that the bacilli were not identical with those commonly causing Johne's disease in cattle.

Unfortunately owing to the complete absence of facilities for maintaining any of the farm animals under experimental conditions it was impossible to attempt infection experiments of calves and ascertain the effect of the bacilli on these animals.

### Contagious Abortion.

Work on the control of this disease by blood testing and separating the reactors from the non-reactors proceeds with encouraging results, particularly in those herds where there is a conscientious and earnest effort made to take all reasonable precautions to prevent the disease spreading. It is generally regarded that the results amply justify the efforts. The expense of the work to the farmer has been negligible in the majority of cases and the gains considerable.

Immunization experiments, using laboratory animals, are in progress, but it is too early to anticipate the results. Each experiment runs a prolonged course and accordingly results cannot be rapidly obtained.

In one or two herds where it has been impracticable to control the disease by segregation of the infected animals, animals which were negative to the agglutination test and presumably not infected, are being vaccinated every two months with a living culture of *Br. abortus*. Pregnant and non-pregnant animals alike are vaccinated. No untoward results have attended this work ; the vaccine has not caused abortion. It is, however, difficult to estimate the protection it may have conferred as the total number of vaccinated animals is not large and it has been impossible to keep controls, owners being unwilling to leave non-infected animals unvaccinated.

It is hoped that through time the use of the treatment may be estimated.

It is considered most important to vaccinate non-infected cows only, even when these are non-pregnant. When non-pregnant infected cows are vaccinated and subsequently calve normally it is quite unjustifiable to attribute the normal calving to the result of vaccination. Despite this fact vaccine is constantly being inoculated into infected animals ; the practice may be harmless but it vitiates any true interpretation of the value of the vaccine, loading the dice in favour of vaccination.

### Poultry Disease.

An increased use was made of the services of the veterinary department by poultry keepers. If the poultry industry were to make claims upon the services of the department commensurate with its losses it would be quite impossible for the department to cope with even a fraction thereof. At the present time work may be done here and there but its total effectiveness is very little, but the work could be made more effective if it were confined to a much more limited area and were the staff augmented by persons capable of undertaking the work and if common schemes for disease control were followed throughout the country.

Epizootiological evidence shows the necessity of poultry keepers building up their flocks with stock free from heritable and contagious disease. A recognition of this

necessity is shown by the Ministry of Agriculture's Accredited Flock Scheme, but it is difficult to see how this desirable scheme of obtaining and recognizing flocks free from disease may be attained without adequate inspection of the poultry and consistent checking up of the cause of mortality. At the present moment the poultry advisory and veterinary services of the country are totally inadequate for the work and in the meantime disease may be expected to spread and take its toll.

## PUBLICATIONS.

McEwen, A. D. 1933. "Struck." Enteritis and Peritonitis of Sheep Caused by a Bacterial Toxin Derived from the Alimentary Canal. Paper 2. *J. Comp. Path. and Therap.*, 46, 108.

McEwen, A. D. 1933. A Brief Review of the Researches on the Acute Diseases of Sheep on the Romney Marsh. *Jour. S.E. Agric. Coll.*, 32, 171.

Roberts, R. S. 1933. The Practical Value of the Heat-Stable Antigen of *Ch. chauvoei* as an Immunizing Agent. *J. Comp. Path. and Therap.*, 46, 56.

# DAIRY BACTERIOLOGICAL ADVISORY SERVICE

By H. Barkworth.

## 1. Enquiries and Advisory Work.

The total volume of work has been maintained, but despite the long continued fine weather, advisory work and calls were not so numerous as last year. The principal troubles were milking machines, or mastitis. In three cases licence holders were concerned by bad reports from the Public Health Authorities, only two cases of ropiness occurred. In two cases the producers were inclined to accept marrow stem kale as an explanation of taint. A single case, apparently of " acid mastitis " was noticed. Cultures were reported by the Royal Veterinary Research Institute to be of normal type.

In practically all cases a definite result was obtained and advice given accordingly. In three cases of taint the milk reverted to normal before solution of the case.

Three enquiries have been received from the trade on Van Oijen's Test.

The bacteriologist is often asked by producers and others to interpret Public Health reports. These may be clear to a laboratory worker but many laymen are often uncertain, especially in regard to interpreting coli contamination.

It should be noted that the number of advisory samples is of little value. A single sample may solve a case of ropiness, or it may take a series to locate the trouble. In the case of milking machines, the usual practice has been to wash each part with sterilized saline. This swells the total of samples, but usually a single visit locates the trouble, and gives the producer an accurate picture of his weak spots.

Although hot weather set in early, there was a marked intensification of advisory demands in August and September, a circumstance which has been noticed in previous years.

## 2. Intelligence.

*Mastitis.* Mastitis is both a hygienic and a veterinary problem. Infected udders may be a source of high counts in the bulk milk and the possibility of bad udders is therefore considered whenever advisory visits are made. A simple field test is used which is adequate for this purpose, but even so, bad udders are found in almost every herd and usually in excess of the owner's belief, while it is certain that more elaborate laboratory tests, approaching the problem from a strictly veterinary point of view, would disclose still more affected animals. A cow can be infected and infective without a " hard bag " or even a high count.

In 1926 the Laboratory sought to establish a mastitis advisory service to give cheap diagnosis and to educate the producer to the extent and importance of udder troubles, but the necessary veterinary support was not obtainable. Since that date much research has been done on the subject in various countries, and the position as regards diagnosis has been greatly clarified.

There has always been a small but steady flow of samples to the Dairy Laboratory for mastitis tests and the desirability of a Mastitis Diagnosis Service has been under discussion with the Veterinary Advisory Officer, but it is realized that if an adequate service were to be offered, provision would have to be made for a great extension of laboratory work for which neither present accommodation nor funds can provide.

*Milking Machines.* In five cases milk machines faultily sterilized and/or cleansed were the trouble. It is not always realized that a milking machine demands an even stricter cleaning than hand-milking utensils.

In October 1929 a fixed flat rate charge was introduced of 3s. 6d. per sample, any in excess of 100 per year being charged at 3s. During the four years that this has been in force private paid samples have averaged 402 per year (farmers and dairy only). The number of samples per herd is as follows:

26% of senders sent one sample in a year.
36% of senders sent two to four samples in a year.
26% of senders sent two to twelve samples in a year.
12% of senders sent over twelve samples in a year.

Or a quarter of senders sent only one sample and more than half sent less than four per year.

A small fee has been charged for keeping quality which is asked for in 19 per cent. of the samples. London laboratories are now regularly advertising tests at 3s. 6d. per sample.

One dairyman is paying a bonus on the results of competition tests. A special scale of bonus has been worked out to fit the marks scale in the competitions and gives also a summer and winter range.

3. Investigation Work.

Mr. Travers of the Kent Advisory Staff has assisted by taking some samples to show the effect of mixing on the fat and bacterial content of the sample. Thirty samples have been taken to date and the results await a preliminary examination.

It was learnt that a competitor in East Sussex was using a disinfectant soak method (chlorine base) to control the bacterial content of his milking machine. A visit was paid and sample taken, but an adequate judgment would require a series of samples which it has not been possible to secure.

An independent enquiry on the chlorine method has been received from another herd.

The results of tests by Van. Oijen's method have been examined and a report published. A further investigation is planned for November 1933.

A survey of reported milking times was made, and also a new tabulation of the bacteriological results of the past seven years has been completed and the results examined statistically. Technical advice is gratefully acknowledged from Mr. T. N. Hoblyn of the East Malling Research Institute, and my colleague Mr. H. B. Bescoby. The completion of this work has been greatly expedited by the arrival in the College of a calculating machine.

4. The total year's work is as follows: There is an increase in paid samples from dairies and private senders, three competitions instead of two, and more samples from Public Health Authorities.

*Numbers of Samples examined.*

| | Kent. | Surrey. | East Sussex. | West Sussex. | Sundry. | Total. | Remarks. |
|---|---|---|---|---|---|---|---|
| 1. Bacteriological: (*a*) Competitions .. | 344 | 543 | 100 | | | 987 | None of these competitions was completed on 1 Oct. 1933. |
| (*b*) Accredited Schemes | | | — | - | | | |
| (*c*) Reading .. .. | | | | | | | |
| (*d*) Public Health Authorities .. | 48 | | 87 | | | 135 | For four authorities 121 Acid fast. |
| (*e*) Advisory .. .. | 126 | 48 | 3 | — | 3 | 180 | 1 Butter, 6 Acid fast, 5 water, also ropy and mastitis. |
| (*f*) Private senders .. | 121 | 85 | 42 | 91 | — | 339 | |
| (*g*) Others .. .. | 82 | 8 | 22 | 6 | | 115 | |
| 2. Chemical .. .. | | Done by | Chemistry | Labor | atory. | | |
| 3. Various .. .. | | | | | 30 | | Research. |
| | 721 | 684 | 254 | 97 | | 1,786 | |

5. Lectures and Demonstrations.

*Lectures. Sanitary Inspectors.* At the request of the East Kent Branch, the bacteriologist attended the May Meeting and opened a discussion on "Sampling of Milk".

Later the joint meeting of the East and West Kent Branches was held at Wye in June when the Advisory Veterinary Officer kindly gave a paper on "Abortion", and a demonstration of milk testing followed.

Two lectures were contributed to the course at Gillingham Technical Institute for junior Sanitary Inspectors.

*Women's Institute.* The bacteriologist attended a Committee meeting of the East Kent Federation and later a meeting of the Wye Institute to discuss the milk question.

*Dairy Course.* The manager of a co-operative dairy attended for a fortnight while the chemical and bacteriology laboratories arranged a special course on practical testing.

*Shows.* The bacteriologist attended the Dairy Show, The Ice Cream Convention, and exhibits were staged at the Kent Rural Community Fair, the Kent County Agricultural Show, and Tunbridge Wells Show.

*Conferences.* The winter meeting of the A.E.A. was attended, and meeting of the Royal Sanitary Institute, when a paper on milk came under discussion. At the summer meeting of Dairy Bacteriologists a paper on Van Oijen test was read, and results of the statistical investigation on keeping quality were discussed at the Society of Agricultural Bacteriologists.

6. GENERAL.

There has been an increase in all kinds of paid samples. Advisory work has been as usual and general activities have been well maintained. Research has been confined to review of accumulated data of various kinds.

Advisory work by Counties :

| | *Paid samples.* | *Advisory samples.* | *Visits.* | *Advice by letter.* |
|---|---|---|---|---|
| Kent .. .. | 121 | 126 | 9 | 4 |
| Surrey .. .. | 85 | 48 | 3 | 3 |
| East Sussex .. | 42 | 3 | 1 | |
| West Sussex .. | 91 | | | |

7. CO-OPERATION.

It is impossible to trace the origin of all advisory work and new senders. Many addresses are sent direct by the counties, but after eight years there are many ways by which an individual farmer or dairyman may learn of the laboratory. There is some evidence that activities by local Public Health Authorities cause producers to send samples for test, but this is not invariably so.

8. PUBLICATIONS. July 1933.

BARKWORTH, H. Milking Times. *Jour. S.E. Agric. Coll.* No. 32.

The milking times reported by herd owners in the Clean Milk Competitions are tabulated and discussed. A general mean of 6.30 a.m. and 3.30 p.m. exists in the South-Eastern Province. Minor County variances in time and interval exist.

*Idem.* loc. cit. Coliform organisms and Keeping Quality of Milk.

The collected results of 4,900 a.m. and 5,400 p.m. samples over eight years are presented graphically. A loss of up to fourteen hours may occur as due to presence of coliform organisms in 1/1,000th c.cm.

*Idem.* loc. cit. Van Oijen's Test. A rapid method for counting high-class milk.

The technique of the test is described and results obtained compared with results under standard plate count. Close agreement obtains up to 30,000 per c.cm. The Method is cheap, rapid, and considerably reduces the amount of apparatus required for each test, but does not include a result for coliform contamination.

# DEPARTMENT OF AGRICULTURE

By V. R. S. Vickers, V. C. Fishwick, H. B. Bescoby and N. L. Tinley.

## FIELD TRIALS, 1932

The following trials are recorded :—

1. Barley Manuring.
2. Treating barley seed as a control for Net Blotch (*Helminthosporum Teres*).
3. Potato variety trial.
4. Trial to test the effect of removing all but the strongest shoot from potato plants.
5. Mangel manuring.
6. Sugar beet manuring.

1. Barley Manuring (second year of the trial).

This trial, which was carried out at the request of Sir John Russell, F.R.S., was designed to test the effect of nitrogenous, phosphatic and potassic manures on the yield and the effect of nitrogen on the nitrogen composition of barley grain. The arrangement of the plots was in the form of a 4 × 4 Latin Square, each plot being $\frac{1}{80}$ acre and each of the $\frac{1}{80}$ acre plots was subdivided into four $\frac{1}{320}$ acre plots. This formed a complex Latin Square from which the actions and interactions of the various manures were calculated. The sampling method of harvesting was employed and the grain was threshed and analysed at Rothamsted Research Station.

*Series A. To test the effect of Nitrogenous Manures.*

Plot 1. *148 lb. Nitrate of soda per acre.

Plot 2. *112 lb. Sulphate of ammonia per acre.

Plot 3. *256 lb. Ammonium humate per acre.

Plot 4. No nitrogen.

* ·2 cwt. of nitrogen per acre.

*Series B. To test the effect of Superphosphate.*

Plot 1. †242 lb. Superphosphate per acre.

Plot 2. No Superphosphate.

† ·4 cwt. of phosphoric acid per acre.

*Series C. To test the effect of Sulphate of Potash.*

Plot 1. ‡139 lb. Sulphate of potash.
Plot 2. No Sulphate of potash.

‡ ·6 cwt. of potash per acre.

The previous crop was barley which was not manured.

The seed, Plumage Archer, was drilled on March 9th at the rate of 3 bushels per acre, the manures being applied on March 11th and harrowed in. The crop was sampled on August 11th.

During growth the nitrate of soda and sulphate of ammonia plots looked the greenest and best, the ammonium humate plots were not noticeably better than the no-manure plots.

*Results.*

*Average Yield. Cwt. per acre.*

*Grain.*

| | No Nitrogen. | Sulphate of Ammonia. | Nitrate of Soda. | Ammonium Humate. | Means. |
|---|---|---|---|---|---|
| No potash or super .. | 27·0 | 31·7 | 31·7 | 26·5 | 29·2 |
| Sulphate of potash .. | 24·5 | 27·3 | 28·6 | 28·6 | 27·2 |
| Superphosphate .. .. | 30·5 | 32·2 | 29·3 | 27·2 | 29·8 |
| Potash and super .. | 26·5 | 28·8 | 29·4 | 28·8 | 28·4 |
| Means .. .. | 27·1 | 30·0 | 29·8 | 27·8 | 28·7 |

Standard error for nitrogen treatment .. 2·63 cwt. or 9·2 per cent.
Standard error for mineral treatment .. 4·40 cwt. or 15·4 per cent.

*Straw.*

| | No Nitrogen. | Sulphate of Ammonia. | Nitrate of Soda. | Ammonium Humate. | Means. |
|---|---|---|---|---|---|
| No potash or super .. | 31·2 | 41·5 | 42·2 | 30·9 | 36·5 |
| Sulphate of potash .. | 28·5 | 34·0 | 36·8 | 33·6 | 33·2 |
| Superphosphate .. .. | 36·3 | 41·1 | 37·5 | 32·1 | 36·7 |
| Potash and super .. | 31·8 | 37·3 | 38·8 | 36·4 | 36·1 |
| Means .. .. | 32·0 | 38·5 | 38·8 | 33·2 | 35·6 |

Standard error for nitrogen treatment .. 4·21 cwt. or 11·8 per cent.
Standard error for mineral treatment .. 6·47 cwt. or 18·2 per cent.

The significant differences may be taken as three times the standard errors. The errors of the experiment are high and there are no significant differences either in the grain or straw yields. There is a distinct tendency for the sulphate of ammonia and nitrate of soda to show increased yields, the ammonium humate having little effect. Potash applied to the no-nitrogen and the sulphate of ammonia plots appeared to depress the yields.

A composite analysis has been made of several of these experiments in different parts of the country, and, although not significant individually, the nitrogen effects show significance on the combined data.

*Nitrogen Content.*

| | No Nitrogen. | Sulphate of Ammonia. | Nitrate of Soda. | Ammonium Humate. |
|---|---|---|---|---|
| Mean .. .. | 1·242 | 1·278 | 1·298 | 1·238 |

| | No Phosphate. | Phosphate. | No Potash. | Potash. |
|---|---|---|---|---|
| Mean .. .. | 1·268 | 1·275 | 1·274 | 1·269 |

These figures have been statistically examined as part of a larger series and the main finding is that nitrogen tends to increase the nitrogen percentage to a small but significant extent whereas the effect of the mineral manures is smaller, more irregular and as a rule not significant.

2. Treating Barley Seed with Various Dressings as a Control of Leaf Net Blotch (*Helminthosporum Teres*) of Barley (first year of trial).

Plumage Archer seed was selected from an infected crop and was dressed with the following materials :—

1. Ceresan.
2. Agrosan A.
3. Agrosan B.
4. Mercuric Chloride dust.

All these materials were in powder form and were mixed with the seed. Sufficient seed was left untreated as a control.

The seed was drilled on February 5th.

By the beginning of July all the plots were infected with the disease, therefore the extent of the control could only be measured during the early stages.

The infection points were counted on May 19th and June 2nd. The results of the two counts were as follows :—

| | Infection. May 19th. | Infection. June 2nd. |
|---|---|---|
| Control (untreated) .. .. .. .. | 91% | 100% |
| Mercuric Chloride .. .. .. .. | 11% | 56% |
| Agrosan A. .. .. .. .. .. | 8% | 30% |
| Agrosan B. .. .. .. .. .. | 6% | 27% |
| Ceresan .. .. .. .. .. .. | 5% | 22% |

This shows that during the early stages of growth the disease was controlled successfully by all the materials used, although there was no significant difference between any of the treatments.

The crop was exceptionally heavy and was laid at harvest. This rendered the cutting of the plots difficult and yields could not be taken.

3. POTATO VARIETY TRIAL (third year of trial).

The following varieties were tested for the third year :—

(1) Arran Consul.
(2) Arran Banner.
(3) Seedling 675.
(4) King Edward.

This year once grown seed was used instead of new Scotch seed.

The plots were laid out in a 4 × 4 Latin Square, there being $\frac{1}{40}$ acre plots of each variety. The potatoes were planted on April 19th and dug by hand on September 30th.

*Yield in Tons per acre.*

| | Chats. | Seed. | Ware. | Total. |
|---|---|---|---|---|
| Arran Consul .. | ·31 | 1·24 | 11·81 | 13·36 |
| Arran Banner .. | ·41 | 1·03 | 10·19 | 11·63 |
| Seedling 675 .. | ·83 | 1·95 | 7·88 | 10·66 |
| King Edward .. | ·50 | 1·92 | 7·36 | 9·78 |

Standard error .. .. ·49 tons.

Arran Consul again proved to be the heaviest cropper and all the varieties gave considerably heavier yields than King Edward. Arran Consul again showed exceptional powers of resistance to Potato Blight, the plots remaining green almost until they were dug.

4. TRIAL TO TEST THE EFFECT OF LEAVING ONLY THE STRONGEST SHOOT ON POTATO PLANTS.

This trial was carried out on three varieties: Majestic, Great Scot and King Edward.

The surplus shoots were removed in June and again in July. During growth there was no marked difference in the date of flowering or in disease resisting powers between the control plots and the singled plots.

The plots were dug by hand on September 22nd. The yields were as follows :—

| | Lb. from all Plots. | | | | % of Ware to |
|---|---|---|---|---|---|
| *Majestic.* | Ware. | Seed. | Chats. | Total. | total yield. |
| Control .. .. | 98 | 21 | 7 | 126 | 77·7 |
| Singled .. .. | 77 | 11 | 4 | 92 | 83·7 |
| *Great Scot.* | | | | | |
| Control .. .. | 107 | 13 | 5 | 125 | 85·6 |
| Singled .. .. | 98 | 7 | 3 | 108 | 90·7 |
| *King Edward.* | | | | | |
| Control .. .. | 83 | 30 | 8 | 121 | 68·6 |
| Singled .. .. | 75 | 21 | 6 | 102 | 73·5 |

The singling reduced the total yield and the yield of ware although the actual percentage of ware was increased.

5. MANGEL MANURING TRIAL (first year of trial).

This trial was designed to test the effect of various forms of nitrogenous manure. The plots were laid out in the form of a 5 × 5 Latin Square, there being five replications of each treatment. The previous crop was wheat top-dressed with ½ cwt. of sulphate of ammonia.

A basal dressing was applied consisting of :—

12 tons per acre farmyard manure.
4 cwt. per acre superphosphate.
2 cwt. per acre muriate of potash.

The following nitrogenous manures were used in addition to the above :—

Plot 1. *216 lb. Sulphate of ammonia per acre.
Plot 2. † 72 lb. Sulphate of ammonia per acre.
Plot 3. *559 lb. Ammonium humate per acre.
Plot 4. *1,056 lb. Humic acid per acre.
Plot 5. No nitrogen.

* ·4 cwt. nitrogen per acre.
† ·148 cwt. ammonia nitrogen per acre.

Throughout growth, the plots which received sulphate of ammonia were very conspicuous. The plots dressed with humic acid were not perceptibly better than the control plots until August when they improved considerably. The plots receiving ammonium humate appeared better than the control plots throughout the growing period.

The mangels were pulled on October 11th. The yields were as follows :—

| | Tons per acre. | % of mean. |
|---|---|---|
| Sulphate of ammonia .. .. .. .. | 20·8 | 120·9 |
| Ammonium humate .. .. .. .. | 18·6 | 108·2 |
| ⅓ dressing of sulphate of ammonia .. .. | 17·3 | 100·5 |
| Humic acid .. .. .. .. .. | 15·6 | 90·7 |
| Nil .. .. .. .. .. .. | 13·7 | 79·7 |
| Mean .. .. .. .. .. .. | 17·2 | 100·0 |

Standard error .. .. .. ·48 ton.

Significant difference .. .. 1·44 tons.

There is a significant difference between each of the treatments with the exception of ammonium humate and ⅓ dressing of sulphate of ammonia. The difference between these two just fails to be significant.

6. SUGAR BEET MANURING.

This trial was carried out at the request of Sir John Russell, F.R.S.

The plots were designed in the form of a 5 × 5 Latin Square giving 25 plots each of $\frac{1}{50}$ acre. Each of the plots was subdivided into four plots of $\frac{1}{200}$ acre, making a total of 100 plots in a complex Latin Square. The previous crop was wheat top-dressed with ½ cwt. of sulphate of ammonia.

*Series A. To test the effect of Nitrogenous Manuring.*

Plot 1. *272 lb. of Nitrate of soda per acre.
Plot 2. † 78 lb. of Sulphate of ammonia per acre.
Plot 3. *234 lb. of Sulphate of ammonia per acre.
Plot 4. *559 lb. of Ammonium humate per acre.
Plot 5. No nitrogen.

* ·4 cwt. of nitrogen per acre.
† ·148 cwt. of ammonia nitrogen per acre.

*Series B. To test the effect of Superphosphate.*

Plot 1. *300 lb. Superphosphate per acre.
Plot 2. No Superphosphate.

* ·5 cwt. phosphoric acid per acre.

*Series C. To test the effect of Muriate of Potash.*

Plot 1. *162 lb. Muriate of potash per acre.
Plot 2. No Muriate of potash.

* ·75 cwt. potash per acre.

During growth the plots dressed with nitrate of soda and the full dressing of sulphate of ammonia were greener and stronger than the rest. The plots dressed with the small dressing of sulphate of ammonia were superior to the control plots. The plots receiving ammonium humate were not perceptibly better than the control plots. All the plots received a basal dressing of 12 tons of farmyard manure.

This was the first year of the ammonium humate, superphosphate and potash trials and the third year of the nitrate of soda and sulphate of ammonia trials.

The plots were lifted, topped and weighed on October 6th, 7th and 8th. The results were as follows :—

*Weight of Roots (unwashed) and tops in tons per acre on Nitrogen Plots.*

| | Roots. | % of Mean. | Tops. | % of Mean. |
|---|---|---|---|---|
| Nitrate of soda .. .. .. | 15·19 | 107·1 | 10·38 | 117·3 |
| Sulphate of ammonia .. .. | 15·04 | 106·0 | 9·61 | 108·5 |
| Ammonium humate .. .. | 13·89 | 97·9 | 8·42 | 95·1 |
| ⅓ Sulphate of ammonia .. .. | 13·74 | 96·9 | 8·26 | 93·3 |
| Nil .. .. .. .. .. | 13·07 | 92·1 | 7·60 | 85·8 |
| Mean .. .. .. .. .. | 14·19 | 100·0 | 8·85 | 100·0 |
| Standard error .. .. | ·191 | ·337 | | |
| Significant difference .. | ·573 | 1·011 | | |

Nitrate of soda and sulphate of ammonia produced yields of roots 2 tons per acre heavier than the no-nitrogen plots. There was no significant difference between the two. ⅓ dressing of sulphate of ammonia and ammonium humate just show a significant increase of roots over the no-nitrogen plots. The difference between nitrate of soda and sulphate of ammonia is more marked in the case of tops, but the difference is not significant.

*Sugar Content.*

| | Sugar %. |
|---|---|
| No nitrogen .. .. .. .. .. .. | 17·63 |
| ½ dressing Sulphate of ammonia .. .. .. | 17·31 |
| Sulphate of ammonia .. .. .. .. .. | 17·42 |
| Nitrate of soda .. .. .. .. .. .. | 17·64 |
| Ammonium humate .. .. .. .. .. | 17·55 |
| Mean .. .. .. .. .. .. | 17·51 |
| Standard error .. .. .. .. | 0·12 |
| Significant difference .. .. .. .. | 0·36 |

There are no significant effects and the usual depression due to nitrogenous manuring is not pronounced in this case.

## FARM RECORDING.

### (*a*) Weather Records and the Effect on Crops.

1931. *October.*—Extremely dry, measurable rain falling on only four days. ·49 in. rain was recorded. Normal for South-East England 3·46 in. Seven ground frosts were recorded, the lowest grass minimum reading being 13° F. on the 28th. Sunshine hours per day 3·77. Normal South-East England 3·44.

*November.*—This month was very wet, some rain falling on twenty-eight days with a total fall of 4·58 in. Normal for South-East England 3·07 in. Only six ground frosts were recorded, the lowest reading being 25° on the 22nd. Sunshine hours per day 1·66. Normal for South-East England 2·15. Mean temperature 46·0°. Normal South-East England 44·9°. Wheat was drilled during this month.

*December.*—This month was very dry, only ·46 in. of rain being recorded. Normal for South-East England 3·11 in. Thirteen ground frosts were recorded, the lowest reading being 15° F. on the 19th. Sunshine hours 1·30. Normal South-East England 1·44. Mean temperature 40·6°. Normal South-East England 41·3°.

1932. *January.*—2·28 in. rain were recorded. Normal South-East England 2·20 in. Thirteen ground frosts were recorded, the lowest reading being 11° on the 1st. Sunshine hours per day 1·67. Normal South-East England 1·68. Mean temperature 41·9°. Normal South-East England 39·4°.

*February.*—Dry and rather colder than the average. Only ·74 in. rain was recorded. Normal South-East England 2·05 in. Sixteen ground frosts were recorded. Sunshine hours per day 2·85. Normal South-East England 2·64. Mean temperature 36·8°. Normal South-East England 40·1°. Marvellous oats drilled on 3rd and 4th. Plumage Archer barley drilled 5th to 23rd.

*March* was drier and slightly colder than normal. 1·57 in. rain were recorded. Normal South-East England 2·05 in. Twenty-two ground frosts were recorded. Sunshine hours per day 4·68. Normal South-East England 3·94. Mean temperature 40·0°. Normal South-East England 42·1°. Owing to drying winds March seed beds were rather rough. Plumage Archer barley sown 10th and 11th. Germination of February sown corn very slow.

*April.*—Wetter and slightly colder than average. 2·51 in. rain were recorded. Normal South-East England 1·69 in. Twelve ground frosts were recorded. Sunshine hours per day 4·37. Normal South-East England 5·65. Mean temperature 45·1°. Normal South-East England 46·7°. Potato planting carried out under very wet conditions between 12th and 24th. Golden Tankard mangel drilled on 30th.

*May.*—Wetter and slightly colder than average. 2·80 in. rain were recorded. Normal South-East England 1·77 in. Four ground frosts were recorded. Sunshine hours per day 4·25. Normal South-East England 6·90. Mean temperature 51·5°. Normal South-East England 52·2°. Remainder of Golden Tankard mangel drilled 17th. Those sown on April 30th showed above ground May 16th. Early potatoes damaged by frost May 12th.

*June.*—Drier and slightly colder than normal. 1·08 in. rain were recorded. Normal South-England 1·89 in. Sunshine hours per day 6·67. Normal South-East England 7·20. Mean temperature 56·7°. Normal South-East England 57·7°.

*July.*—Very wet at the end of the month. 4·00 in. rain were recorded. Normal South-East England 2·17 in. Sunshine hours per day 5·32. Normal South-East England 6·96. Mean temperature 61·5°. Normal South-East England 61·1°.

*August.*—Drier and warmer than normal. 1·19 in. rain were recorded. Normal South-East England 2·32 in. Sunshine hours per day 7·04. Normal South-East England 6·48. Mean temperature 65·0°. Normal South-East England 60·9°. Oats were cut on August 8th. Barley was cut between the 10th and 25th and wheat between the 16th and 29th. Wild white clover for seed was cut during the first week and carted during the second week of the month.

*September.*—Slightly drier than normal. 2·42 in. rain were recorded. Normal South-East England 2·13 in. Sunshine hours per day 3·86. Normal South-East England 5·43. Mean temperature 57·7°. Normal South-East England 57·3°. Corn carrying was completed by the 19th. Potato lifting began on the 29th.

(*b*) Dates of Drilling and Planting.

| | 1929-30. | 1930-1. | 1931-2. | 1932-3. |
|---|---|---|---|---|
| Spring Oats .. | Feb. 27-Mar. 10. | Mar. 17-18. | Feb. 3-Mar. 30. | Mar. 10. |
| Spring Wheat .. | — | — | Feb. 1. | — |
| Wheat .. | Oct. 4-22. | Oct. 20-Nov. 4. | Nov. 2-13. | Oct. 19-Dec. 15. |
| Barley .. | Feb. 25-Mar. 6. | Mar. 14-26. | Feb. 5-Mar. 11. | Mar. 13-15. |
| Potatoes .. | Apr. 12-24. | Apr. 8-17. | Apr. 12-24. | Mar. 29-Apr. 2. |
| Mangels .. | May 1. | May 6. | May 2-17. | Apr. 15-22. |
| Kale .. | — | — | — | Apr. 4. |
| Sugar Beet .. | May 8. | May 6. | May 17. | — |
| Peas .. | — | — | — | Apr. 27. |

(*c*) Dates of Harvesting.

| | 1929. | 1930. | 1931. | 1932. |
|---|---|---|---|---|
| Seeds Hay .. | — | June 7-19. | June 5-16. | June 9-16. |
| Corn .. | Aug. 7-30. | July 31-Aug. 27. | Aug. 7-28. | Aug. 8-29. |

(*d*) Crop Yields per Acre.

| | 1929. | 1930. | 1931. | 1932. | *Average 10 years England and Wales.* |
|---|---|---|---|---|---|
| Wheat (bushels) .. | 53 | 32 | 22½ | 39 | 31 |
| Spring Oats (bushels) | 76 | 66 | 57½ | 56 | 38½ |
| Spring Wheat (bushels) | — | — | — | 30 | — |
| Barley (bushels) .. | 58 | 38 | 32 | 50 | 30½ |
| Mangels (tons) .. | 33 | 37 | 28 | 22 | 19 |
| Potatoes (tons) .. | 6¾ | 6½ | 6 | 5 | 6 |
| Sugar Beet (tons) .. | 11¼ | 13 | 14¾ | 13 | 8 |

College Farms.

*Cropping and Pasture.*

| Arable. | 1930-1. | 1931-2. | 1932-3. | Grass. |
|---|---|---|---|---|
| *Cold Harbour.* | | | | Barn Field |
| Field A | Grazing seeds | Potatoes<br>Grazing seeds | Wheat | Upper Wallaways |
| Field B | Mowing seeds | Grazing seeds | Grazing seeds | |
| Field C | Barley<br>Potatoes | Mowing seeds<br>Oats | Grazing seeds<br>Peas | |
| Field D | Barley | Barley | Wheat | |
| Wallaways | Barley | Barley | Barley | |
| The Park | Mangels<br>Market Garden crops | Wheat<br>Oats | Wheat | |
| *Silks.* | | | | Old Orchard |
| Field 1 | Barley | Mowing seeds | Grazing seeds | Goldup Meadow |
| Field 2 | Red Clover | Barley | Barley | Cooks |
| Field 3 | Barley | Barley | Oats | Forstal |
| Field 4 | Oats | Spring Wheat | Mangels | Crabbs & Tilbees |
| Field 5 | Oats | Grazing seeds | Grazing seeds | Brook Field |
| Field 6 | Grazing seeds | Grazing seeds | Kale<br>Potatoes | Pilrags |

*Amage.*

| | | | |
|---|---|---|---|
| Long Field | Grazing seeds | Grazing seeds | Grazing seeds |
| Middle Field | Wheat | Mangels | Wheat |
| Bushy Field | Wheat | Wheat | Mowing seeds |
| Westons | Barley | Barley | Mowing seeds |
| Little Crabbs | Market Garden crops | Oats | Wheat oversown with Oats |

## SHEEP.

Mr. N. L. Tinley has continued his experimental work on sheep on the College Farm. A survey of the Suffolk breed has been carried out during the year, an article has been written on the breed and reprints of this have been sent to those breeders who contributed information and to the Suffolk Sheep Society.

### The Effect of Protein-Rich Meal on Wool Production.

This experiment, which was begun in June 1931, has been continued and two years' results are now available. Blood meal was fed to the ewes at the rate of 3 oz. per head per week from 7 November until 15 May, the cost of this feeding being 1s. per head. The lambs from each group were weighed at birth and the fleeces were weighed at shearing time, with the following results :—

*Fleece Weights.*

| | June 1931. | June 1932. | June 1933. |
|---|---|---|---|
| Control .. .. .. | 7 lb. 10 oz. | 6 lb. 5 oz. | 6 lb. 0⅜ oz. |
| Blood meal .. .. | 7 lb. 8 oz. | 7 lb. 3 oz. | 6 lb. 6¼ oz. |

These figures show that in June 1932 at the end of the first year of the experiment the blood meal fed group produced 14 oz. more wool than the control group. The ewes were then re-sorted so that the wool production of the two groups was again equal. During the second year of the experiment, the blood meal fed group produced 6 oz. more wool than the control fed group. The average of the two years is therefore 10 oz. per head increased wool production or approximately 10 per cent.

*Weight of Lambs at Birth.*

| | 1932. | 1933. |
|---|---|---|
| Control .. .. .. .. | 9·94 | 9·58 |
| Blood meal .. .. .. | 10·72 | 10·07 |
| Increase .. .. .. | ·78 lb. | ·49 lb. |

In both years the birth weight of the lambs was substantially heavier from the blood meal group of ewes. The number of lambs born from the two flocks was almost the same each year.

The experiment is being continued for a third year, when a full report of the trial will be written.

### Testing Wool for Medullated Fibre.

At the request of the flock owner, wool from the ram tegs and stock rams of his flock was tested for medullated fibres and a full report given.

### The Effect of Shearing Lambs.

In June 1932 the Kent ewe lambs on the College Farm were divided into two equal groups by weight. One group was shorn and the other was not.

In June 1933 when they were shorn as tegs the following live weights and fleece weights were recorded :—

| | Average Live weight unshorn, June 1932. | Wool per head, June 1932. | Average Live weight shorn, June 1933. | Wool per head, June 1933. | Total weight of wool produced. |
|---|---|---|---|---|---|
| Unshorn Group .. | 58·66 | Nil | 111·83 | 8 lb. 4 oz. | 8 lb. 4 oz. |
| Shorn Group .. | 58·69 | 1 lb. 8½ oz. | 109·15 | 7 lb. 0 oz. | 8 lb. 8½ oz. |
| Difference .. | | | 2·68 | | 4½ oz. |

### Ewe Feeding Trial in Romney Marsh.

In the spring of 1933 a feeding trial was carried out with four hundred Kent ewes near Camber in the Romney Marsh. The ewes were divided into two groups and the trial began on 5 March. One group was fed on ½ lb. per head per day of beans and the other group received ¾ lb. per head per day of a proprietary food containing 22 per cent. albuminoids and 5½ per cent. oil. This was in the form of cubes and could be fed on the ground without the use of troughs. The bean ration supplied ·70 lb. albuminoids and ·038 lb. oil per sheep per week ; the experimental ration supplied 1·15 lb. albuminoids and ·289 lb. oil per week. After lambing the experimental ration was increased to 1 lb. per head per day. The bean ration remained the same.

It was hoped that the increased feeding would enable those ewes which produced twins to rear their lambs better. The twins were weighed at birth ; those from the bean fed group weighed 19·77 lb. per pair and those from the other group 19·15 lb. per pair.

On 17 May the lambs were weighed again. The lambs from the bean fed ewes weighed 30·58 lb. per head, whereas the lambs from the other group weighed 27·76 lb.

In each group approximately 25 per cent. of the twins born were lost. It is this very heavy loss which the experimental feeding was intended to cure.

## PIG HUSBANDRY RESEARCH SCHEME.

The breeding herd has consisted of Large Black sows since the summer of 1929. These have been crossed with Middle White boars. The progeny of this cross make very good pork pigs but are generally too fat for bacon production. In making necessary replacements of stock a group of Large White gilts and a Large White boar have been acquired which will enable pigs of the type required for bacon production to be bred.

The Large Whites did not produce their first litters until late in the summer (1933); the work recorded below was carried out with Large Black sows and their progeny by a Middle White boar.

THE FEEDING AND MANAGEMENT OF BREEDING STOCK.

It was stated in the report for 1931-2 (Vol. 31, page 61, para. 3) "that an analysis of the results obtained during the three preceding years indicated that the growth of young pigs can be influenced in a marked degree by the feeding of their dams. The secret of success in rearing young pigs appears to lie in liberal feeding of the sow during the first month of the nursing period. The best results, during the period under discussion, were obtained from sows which received all they would clear up twice daily from the third day after farrowing of a mixture containing 15·2 per cent. of digestible protein. This observation was confirmed in the current year, it being found that the sows reached their maximum quantity—14-16 lb. per day—when their pigs were between two and three weeks old.

It was recorded in the 1932 report (Vol. 29, p. 50) that results had been obtained which indicated that " It is easier to rear young pigs which are allowed to run out on grass with their dams than those confined to styes, the former making more growth and suffering less from scour than the latter. Young pigs which run out start to eat when about four weeks old, those confined to styes do not as a rule start to eat until they are five weeks old."

Unfortunately on some farms it is not convenient to allow sows and their litters out to graze and *on a very large number of farms* it is not desirable to do so during the winter months. Under the conditions created by the Pig Industry Reorganization Scheme it is essential that sows should be farrowed at regular intervals throughout the year, *and the success of the scheme will depend in a large measure upon the ability of farmers to rear pigs indoors*. The whole resources of this centre have therefore been concentrated upon the systematic study of the rearing of young pigs which are confined to styes with a view to discovering methods of obviating the troubles so consistently encountered when pigs are reared in this manner ; troubles which are frequently so acute during the winter months that many farmers avoid farrowing between September and March, a practice fatal to the smooth working of the Reorganization Scheme.

In the initial stages of this investigation the method of trial and error has been used with a view to ascertaining the primary factors contributing to success and failure. Results of considerable practical importance have already been obtained. All the pigs produced during the past year have been reared on the indoor system. Four hundred and sixty-one pigs were born alive between July 1932 and August 1933, of which 89 per cent. were reared. During the months February to July (inclusive), 94 per cent. of the pigs born were reared, and seventy young pigs reared on System 7, referred to below, had the condition and bloom which is usually only obtained with milk feeding.

Brief notes on the trials carried out are appended.

It has been observed during the past three years that there is a correlation between the growth of a litter of pigs and the age at which it starts to eat. Generally speaking the best litters are those which start to eat supplementary food when they are between two and three weeks old and subsequently develop a healthy appetite. It has also been observed that pigs reared indoors rarely start to eat before they are five weeks old and between the ages of five and seven weeks eat very little. Frequently indoor litters show

no inclination to eat until they are six or seven weeks old. The trials referred to below were carried out with the object of ascertaining under what conditions, if any, a young pig could be induced to start eating supplementary food when between two and three weeks old.

No. 1. Placing a creep in the wall of the styes through which only the little pigs could pass. This was opened during the day so that the young pigs could get out into a grass run adjoining the styes. The troughs containing the supplementary food for the young pigs were put into the grass run. Three or four litters were allowed to run out together and it was found during the late summer that the older pigs taught the young ones to eat. At this period of the year the method answered fairly well, *but it failed during the autumn.* It was found in bad weather that the young pigs remained with their dams, showing no inclination to avail themselves of the opportunity to go out and graze.

N.B.—When pigs are kept on the open-air system the sows go out whenever the weather is favourable and the pigs follow them.

No. 2. Feeding the sow on dry food. When a sow is given dry food she takes longer to eat her ration than if fed " wet ". Young pigs are very inquisitive and it was thought possible that seeing their mother at the food trough might induce them to follow her example. This actually happened, and the litters which were raised on this system did start to eat from their mother's trough at three weeks old. The sows, however, dropped their milk yield to a noticeable extent and the young pigs became unthrifty and lost their appetite, the method proving a complete failure. This trial was carried out in December at a time when the weather was very cold and it appears probable that the fall in the sows' milk yield was due to the observed fact that they did not drink sufficient water.

No. 3. The use of special foods :—split peas, kibbled linseed cake, locust beans, and the addition of fenugreek to normal meal rations were tried without finding anything which appeared to be specially attractive to the young pigs.

No. 4. The use of (*a*) warm food, (*b*) dry food was not successful.

No. 5. Early weaning. A group of litters which showed but little tendency to eat were weaned at six weeks old. The young pigs received a very serious check after weaning, and did not develop a normal appetite, the method proving a failure. It would appear to be essential that young pigs should have learned to eat before weaning if it is desired to wean at this age.

No. 6. Grass cuttings. Young grass cut by a lawn mower was readily eaten by young pigs, but did not appear to increase the tendency of the young animals to eat meal. The young pigs in this group made better growth than did those which did not eat anything until they were five weeks old but compared unfavourably with those reared by Method No. 7.

No. 7. The use of liver, lean meat and blood meal. In the spring of 1933 a trial was made with liver. This was offered to young pigs which had refused to eat an ordinary meal mixture and split peas. The pigs ate the first ration of liver in half an hour, subsequent rations being eaten up greedily in two or three minutes, the pigs exhibiting great

keenness to obtain it. They clamoured round the attendant's feet as soon as he entered the stye and snatched the liver from his hands. The quantity used was ¼ oz. per pig. The supply of liver is, however, strictly limited, and its use as a pig food, except in getting up show pigs, is impracticable. It was therefore decided to try lean meat. This was found to be a very good substitute ; young pigs did not eat it quite as greedily as the liver but it was eaten readily by young pigs from the time they were two weeks onwards. When the young pigs got used to the taste of the meat it was buried in dry meal—for the first few days the young pigs picked the meat out from the meal, but after doing this for a few days they got used to the taste of the meal and started to eat a small quantity of this also. A meal mixture was used which contained 5 per cent. of blood meal and when the young pigs were eating an appreciable quantity of this the meat was discontinued.

Blood meal was tried as a substitute for meat, but it was not eaten by the young pigs ; our observations indicate that this food has a very beneficial action on young pigs between six and eight weeks old and it has therefore been included in the meal ration used when the meat is discontinued. The quantity of meat used in these trials was ¼ oz. per pig per day, the period for which it was required varying between two and four weeks, e.g. a maximum of 7 oz. per pig. Thus the cost was negligible. The pigs reared in the way outlined above at weaning had the condition and bloom of milk fed pigs.

FEEDING EXPERIMENTS.

The work carried out by Mr. Dunlop at Cambridge on individual feeding has shown the value of this method of feeding in experimental work. Twenty " individual feeding pens " were constructed in the early summer and were used in Experiment No. 30.

THE VALUE OF A RUN OUT ON GRASS FOR GROWING PIGS.

EXPERIMENT NO. 30. Date, 31 May to 25 August 1933.

*Object.* To ascertain the value of the grass and exercise obtained by growing pigs which have free range on grass.

*Method of Working.* Two groups each containing twenty-four pigs in five lots were used. Group A (Lots 1A, 2A, 3A, 4A and 5A) was fed in styes. Group B (Lots 1, 2, 3, 4 and 5) had free range on grass. The lots were formed by pairing, each lot in Group B received the same quantity of food as the comparable lot in Group A. The pigs in Lots 1A and 2A and the two comparable Lots 1B and 2B were fed individually. The experimental period for each lot started when the average weight of the lot was as near as possible to 60 lb.

| *Rations.* | First Month. | Second Month. |
|---|---|---|
| Barley Meal .. .. .. | 25% | 25% |
| Maize Meal .. .. .. | 20% | 20% |
| Sharps .. .. .. | 45% | 45% |
| Fish Meal .. .. .. | 10% | |
| Soya Bean Meal .. .. .. | | 10% plus minerals* |

* Mineral mixture 1½ lb. chalk, ½ lb. salt per 100 lb. mixed meal.

*Notes.* The pens were stocked lightly and in spite of the dry weather there was a moderate amount of grass available for the pigs until Lots 3 and 4 had completed their second months.

The weather was at times abnormally hot and the only shade in the outdoor pens was that provided by the shadow thrown by the hut, thus these pigs received no more protection from the sun than did those in the indoor group.

*Results.*

1. *Weights.*

| | First month (Average 24 pigs). | | Second month (Average 10 pigs). | |
|---|---|---|---|---|
| | Group A (Indoors). | Group B (Outdoors). | Group A (Indoors). | Group B (Outdoors). |
| | lb. | lb. | lb. | lb. |
| Starting weight .. .. | 58·6 | 61·6 | 89·0 | 90·2 |
| Finishing weight .. | 85·2 | 91·1 | 116·9 | 119·9 |
| Increase .. .. .. | 26·6 | 29·5 | 27·9 | 29·7 |
| Meal consumed .. .. | 82·12 | 83·85 | 107·5 | 107·5 |
| Meal consumed per 1 lb. live weight increase .. | 3·08 | 2·84 | 3·86 | 3·62 |

2. *Health.* All the pigs in Group B (the outdoor group) made excellent growth. No case of ill-health was observed amongst these pigs. Those in Group A made satisfactory growth during the first month of the experimental period, but nine pigs in this group suffered from digestive disturbances during the hot weather which prevailed in the second month and three lots (1A, 2A and 5A) had to be withdrawn. These pigs were put into open-air runs, all of them subsequently recovering within fourteen days.

3. Throughout the experimental period the pigs in the indoor group (A) received all they would clear up, the same quantity of food proving insufficient to satisfy the appetite of the comparable outdoor lot, all of the pigs in which showed unmistakable signs of hunger throughout the trial.

4. There was an adequate supply of grass throughout the whole of the first month of the experimental periods, and during this period the outdoor pigs showed unmistakable signs of hunger, the inference being that they ate the maximum amount of grass.

5. The figures indicate that the food value to the pigs of the grass eaten was extremely small.

EXPERIMENT NO. 28. Date, 19 May to 13 June 1933.

*Object.* To ascertain the value of allowing growing pigs free range on grassland.

*Method of Working.* Thirty-two strong stores having an average weight of 40 lb. which had had free range on grass since weaning, were divided into two groups, by the method of " pairing by weight ". Group 2 was fed in the styes, Group 1 was allowed free range on grass. The pigs were fed all they would clear up readily.

| *Rations.* | First Month. | Second Month. |
|---|---|---|
| Barley Meal .. .. .. .. .. | 60% | 60% |
| Sharps .. .. .. .. .. | 30% | 30% |
| Fish Meal .. .. .. .. .. | 10% | |
| Soya Bean Meal .. .. .. .. | | 10% plus minerals* |

* Mineral mixture 1½ lb. chalk, ½ lb. salt per 100 lb. mixed meal.

*Notes.* A fortnight of very hot weather was experienced during the second month.

*Results.*

1. *Weights (average of sixteen pigs).*

| | First Month. | | Second Month. | |
|---|---|---|---|---|
| | Group 1 (Outdoors). | Group 2 (Indoors). | Group 1 (Outdoors). | Group 2 (Indoors). |
| Starting weight .. .. | 47·5 | 46·0 | 80·7 | 77·7 |
| Finishing weight .. | 80·7 | 77·7 | 115·3 | 102·0 |
| Increase .. .. .. | 33·2 | 31·7 | 34·6 | 24·2 |
| Meal consumed .. .. | 88·3 | 83·3 | 108·7 | 88·1 |
| Meal consumed per 1 lb. live weight increase .. | 2·6 | 2·6 | 3·1 | 3·6 |

Average meal consumed per 1 lb. live weight increase over the two-month period :—
Group 1 : 2·9 lb. Group 2 : 3·1 lb.

2. *Health.* No case of ill-health was observed amongst the pigs of Group 1. One pig in Group 2 suffered from digestive troubles during the first week of the third month. It was allowed out to graze and recovered in about fourteen days.

3. During the first fortnight there was no appreciable difference in the appetite of the two groups, but during the second fortnight of the experimental period the outdoor group developed a better appetite than the indoor group. During the second month the difference in food requirements was appreciable, the outdoor pigs eating more meal and making more growth than their indoor mates.

The results obtained in Experiment No. 14 (1931) and Experiment No. 17 (1932) may with advantage be considered in conjunction with those obtained in Experiments Nos. 30 and 28.

In Experiments 14 and 17 comparable groups were fed on rations containing (1) 30 per cent. of sharps and (2) 60 per cent. of sharps, the latter ration containing slightly more fibre than the former. In No. 14 the pigs which had free range on grass fattened on No. 2 ration, making very nearly as rapid growth as those on No. 1 ration, but in No. 17 the pigs which were confined to styes would not eat as much of Ration No. 2 as of Ration No. 1 after they reached 80 lb. live weight.

CONCLUSIONS.

1. *Health.* The figures for summer months of the past three years summarized below are very significant.

| | Pigs running outdoors. | | Pigs confined to Styes. | |
|---|---|---|---|---|
| | No. in Experiment. | No. observed to suffer from digestive troubles. | No. in Experiment. | No. observed to suffer from digestive troubles. |
| Experiment No. 30 .. | 25 | Nil | 25 | 8 |
| Experiment No. 28 .. | 16 | Nil | 16 | 1 |
| Experiment No. 21 .. | 45 | Nil | No comparable | indoor pigs |
| Experiment No. 14 .. | 50 | Nil | 10 | 2 |
| Totals .. .. | 136 | Nil | 51 | 11 |

The eleven pigs which were unwell all recovered, but the disorders from which they suffered occasioned considerable loss of growth.

Digestive troubles are less frequently experienced amongst pigs fed indoors during the autumn, winter and spring, than they are during the summer months.

One hundred and twenty-one of the one hundred and thirty-six pigs which were run out during the growing period in the above trials were transferred to the indoor pens where they were fed intensively for between one and three months. No serious case of ill-health was observed during this period.

2. *Appetite.* It is apparent that pigs running out on grass are more healthy and develop a better appetite than those confined to styes.

3. *Growth Rate.* It would appear that the more rapid growth of the outdoor pigs was due to the fact that they had better appetites and ate more meal than their indoor mates. The food value of the grass eaten appears to be comparatively small.

THE ECONOMY OF A STORE PERIOD (EXPERIMENT NO. 21). Date 15 June to 31 October 1933.

*Object.* To ascertain the economy of a store period for pigs running on grassland during the summer months.

*Method of Working.* Three groups each containing fifteen pigs were formed by the method of " pairing by weight ". The pigs were allowed free range on grassland, Group 1 receiving all the meal they would clear up twice daily throughout the trial, the quantity fed to Groups 2 and 3 being limited.

| *Rations.* | Lot 1 and Lot 2. | Lot 3. |
|---|---|---|
| Sharps .. .. .. .. | 60% | 60% |
| Maize Meal .. .. .. .. | 20% | 20% |
| Barley Meal .. .. .. .. | 10% | 20% |
| Fish Meal .. .. .. .. | 7½% | Plus Minerals* |
| Soya Bean Meal .. .. .. .. | 2½% | |

* Mineral mixture 1½ lb. chalk, ½ lb. salt per 100 lb. mixed meal.

*Results.*

1. The quantities of meal eaten per pig per day :—

| Average for month. | First Month. | Second Month. | Last 23 Days. |
|---|---|---|---|
| Lot 1 .. .. | 2½ lb. | 3 lb. | 5 lb. |
| Lot 2 .. .. | 2 lb. | 2½ lb. | 3 lb. |
| Lot 3 .. .. | 2 lb. | 2½ lb. | 3 lb. |

2. *Weights.*

| | First Four Weeks. | | | Second Four Weeks. | | | Last Three Weeks. | | |
|---|---|---|---|---|---|---|---|---|---|
| Lot .. | 1 | 2 | 3 | 1 | 2 | 3 | 1 | 2 | 3 |
| Starting weight .. .. .. | 45·7 | 46·1 | 47·0 | 70·7 | 65·3 | 62·2 | | 86·4 | 81·4 |
| Finishing weight .. .. .. | 70·7 | 65·3 | 62·2 | 98·0 | 86·4 | 81·4 | | 103·0 | 98·8 |
| Increase .. .. .. .. | 25·0 | 19·2 | 15·2 | 27·3 | 21·1 | 19·2 | | 16·6 | 17·4 |
| Meal consumed .. .. .. | 69·9 | 56·0 | 56·0 | 92·8 | 70·9 | 70·9 | | 62·7 | 62·7 |
| Meal consumed per 1 lb. live weight increase .. .. .. .. | 2·7 | 2·9 | 3·6 | 3·4 | 3·3 | 3·6 | | 3·7 | 3·6 |

Meal consumed between 46 and 100 lb. live weight for each 1 lb. live weight increase :—
Lot 1 : 3·1 lb. Lot 2 : 3·3 lb. Lot 3 : 3·6 lb.

3. At the close of the experiment the pigs were put up to fatten. They were marketed when between 140 and 160 lb. live weight. The carcasses were examined and measurements of back fat made, no difference being detected in the carcasses from the three groups.

## Trials with Fish Meal.

*Object.* To ascertain the conditions, if any, under which the feeding of fish meal containing 9 per cent. of oil caused a taint *in fresh pork.*

*Results.*

1. Whilst the results indicated that, in these trials, the use of up to 20 per cent. of fish meal in the ration of pigs to within twenty-four hours of the time of slaughter, did not taint the fresh pork, it was found that the idea that the use of fish meal will cause a taint is so deeply implanted in the minds of some people that if they think that this food has been used they are apt to imagine that they can taste it in the meat.

2. The contents of the intestines of the pigs had a very characteristic odour. This was absent when the fish meal was discontinued a week before the pigs were sent to the butcher.

3. One pig was scalded in water containing a small quantity of the excreta from fish meal fed pigs. The rind of this pig had a very distinct taint.

4. The flesh of the two pigs fed on the ration containing 20 per cent. of fish meal was of very inferior quality. It was sticky and did not " set ".

In view of the results obtained in this trial it would appear that no trouble is likely to be occasioned with pigs sold for *fresh pork* if the recommendations previously issued from this College are followed, viz. :—

1. That the best white fish meal be used.

2. That the quantity used at no time exceeds 10 per cent. by weight of the ration and that the percentage be reduced to 5 per cent. during the " fattening " period.

3. That the use of fish meal be discontinued fourteen days before the pigs are sent to market.

# PUBLICATIONS.

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*Idem.* 1933. Summary of Experiments carried out in the year 1931-2. *National Pig Breeders' Annual*, 1933.

*Idem.* 1933. Factors essential to success in Pig Breeding. *Farmer and Stockbreeder*, March 1933.

TINLEY, N. L. July 1933. The Southdown Sheep. *Jour. S.E. Agric. Coll.*, No. 32.

*Idem.* July 1933. The Suffolk Sheep. A Survey of the Breed. *Jour. S.E. Agric. Coll.*, No. 32.

*Idem.* July 1933. Influences on the Quality of Kent Wool. *Jour. S.E. Agric. Coll.*, No. 32.

*Idem.* March 1933. The Occurrence of Medullated Fibres in the Fleece of the Romney Marsh Sheep in England. *Jour. of N.F.U.*

*Idem.* June 1933. Main Crop Potato Variety Trials at Wye College. *Jour. of N.F.U.*

# DEPARTMENT OF BOTANY

By S. T. Parkinson, R. T. Pearl and R. M. Harrison.

In addition to the usual routine and advisory work, observational and research work, as set out below, has been carried on by this Department.

## Cereals.

Mr. Irving-Bell continued precision records on two types of wheat, in connection with the Agricultural Meteorological Scheme. The plots were harvested and samples and data forwarded to Rothamsted according to instructions.

## Phenological Garden.

Observations have been continued and reports forwarded to the Ministry of Agriculture.

## Weed Surveys.

In 1930 Mr. R. M. Harrison made a preliminary investigation of Dr. W. E. Brenchley's method of weed surveying. (See *Journal*, No. 28, 1931, pp. 41-7.) This year, adopting the same method, he has made surveys of the weed flora of pea fields in various parts of Kent and was able to correlate his results with soil work which Mr. Furneaux has carried out on the same fields.

Seventy surveys were made, the majority on the alluvial soils of Romney Marsh, ranging from the heavy soils of the Newchurch series to the lighter ones of the New Romney series. Heavy soils of the Weald, fine lighter soils of the Hastings Beds, Lower Greensand soils, and drifts overlying chalk indicate the range in other localities.

The weed survey of arable fields on the College Farm was also continued and interesting correlations with the soil series recently established by Brade-Birks and Furneaux were noted. It is hoped to publish details later in the *Journal*.

## Grassland.

In August and September of 1932 Mr. Harrison carried out botanical analyses of pastures on three soil series in Romney Marsh. Three fields in each series were examined. Results indicated that further fields, of each series, would repay examination; consequently, during the corresponding season this year (1933) eight fields have been analysed. One of these was a field examined last season and it is interesting to note that in spite of the abnormally dry summer the result showed very close agreement with that then obtained.

The method entails estimation of the proportionate area covered by tillers of different species of plants in a six-inch square. One hundred readings were taken in each field. The results are being treated statistically by an analysis of variance.

The investigation has shown that the herbage varies according to the particular soil series, not only in manner of growth but in percentage and variation of species.

Mr. Harrison has also established further additions to his list of host-plants attacked by Dodder.

PYRETHRUM.

Mr. R. K. Eames has continued his observations on the botanical characters of Pyrethrum. The plots of plants, sown at different distances apart, have been harvested and the yield recorded.

The plants selected and subsequently described by Mr. Harrison have been divided and the inflorescences of the resulting clone plants measured and harvested.

PEAS.

The Department has sown, noted and harvested peas from fifty-one different samples. Each strain was grown (1) spreading on the soil, (2) sticked, (3) treated with salt. The Department wishes to thank Messrs. J. C. Thorn, G. S. Douglas-Jones, B. C. and W. A. C. Milne, students of this College, for valuable assistance in carrying out this experiment.

FOODSTUFFS.

More inquiries than usual have been made with respect to substances present in cattle foods. Mr. Lucie-Smith carried out an investigation on the structure of pod seeds of species of the Jack Bean (*Canavalia*) and published his results in the *Journal*, July 1933.

POMOLOGY.

Mr. R. T. Pearl has made further progress with the description of the characters of apple varieties. Observations are being continued and extended on the characters of the inflorescence, fruit and vegetative shoots.

During the year a further paper on the character of the inflorescence has been published, in which the previous literature of the subject is reviewed and the inflorescences of a further fifteen varieties fully described and illustrated.

Preliminary descriptions of the inflorescences of a number of pear varieties are under preparation and there is little doubt that the study of the characters should provide a valuable supplementary means of identification for pear varieties. Nevertheless a number of varieties occur, in which the floral differences appear to be but slight, and further critical study is necessary. Certain characters, such as the colour of the base of the newly formed *bourse*, the size and colour of the anthers, whilst of little significance with apples, may prove valuable in identification of pears.

WYE PROVINCIAL CONFERENCE.

Mr. Pearl has continued to act as convener of the Horticultural Section of the Wye Provincial Conference. Full-day meetings are held three times a year, and this is striking evidence of the valuable work that this section is able to carry out, at a time

when many similar organizations have curtailed their meetings. At the eighteenth meeting of the section in January 1933, Mr. Pearl organized a demonstration of still and moving picture projectors, suitable for county lectures and institutional purposes. Commercial firms which participated in the demonstrations included Messrs. Evans Brothers, Ltd., Messrs. Ensign, Ltd., and Messrs. Visual Information Service.

HORTICULTURAL EDUCATION ASSOCIATION.

The first volume of the *H.E.A. Year Book* (1932) was published under the editorship of Mr. Pearl in December 1932. The publication was well received by the press and favourably reviewed in many horticultural and scientific periodicals, at home and overseas. Its circulation indicates that it is appreciated by a widely distributed public, both in educational circles and the horticultural industry.

At the Annual Conference of the Association in September 1933, Mr. Pearl read a paper on " Visual Aids to Horticultural Education ", which was followed by a comprehensive demonstration of modern picture projectors.

## PUBLICATIONS.

LUCIE-SMITH, M. N. 12 July 1933. Photography as a help in the examination of cattle foods—Structure of the pod and seeds of *Canavalia* spp. *Jour. S.E. Agric. Coll.*, No. 32, pp. 42-8.

PEARL, R. T. 1933. The Inflorescences of Apple Trees. II—An Historical Review together with further Varietal Descriptions. *Jour. S.E. Agric. Coll.*, No. 32, pp. 9-17.

# DEPARTMENT OF ENGINEERING

By Cornelius Davies.

## Conference.

In September 1933 the writer read a paper on "Experiments in Soil Consolidation" at the fifth "Semaine International du Machinisme à la ferme" at Lausanne, which was organized by the Institut International de Mécano-Culture. He also demonstrated the working of the Compactometer. He was elected a "Président d'Honneur" of this Conference.

## Consolidation Experiment.

This experiment, in which it is sought to establish the best method of consolidating the soil for cereal crops, was repeated with barley. A Fordson tractor was used to obtain the necessary consolidation, and the plots were arranged in the form of Randomized Blocks, which system is more convenient than a Latin Square when using large machines. There were four replicates and the following treatments were given:

1. Not consolidated.
2. All the surface consolidated before drilling.
3. All the surface consolidated after drilling.
4. Plots consolidated in strips.

*Results.*

*Field II (Coldharbour Loam).*

*Plots* 1/150 *acre, drilled* 11 *March* 1933.

Yields are in cwt. per acre.

| | Not rolled. | Rolled before drilling. | Rolled after drilling. | Rolled in strips. | Significant difference. |
|---|---|---|---|---|---|
| Grain .. .. | 23·43 | 25·78 | 24·10 | 28·12 | 5·37 |
| Total produce .. | 47·81 | 50·89 | 55·17 | 57·58 | 7·74 |

As far as the total produce (weighed in the field) is concerned the "strip" treatment gave a significantly higher yield. Odds of 20 to 1 are generally required to establish a difference. That being the case there is no significant difference between the grain yields of the "strip" and the "not rolled" plots; but if one is satisfied with 10 to 1 odds the difference here is significant.

## Methods of Sowing.

The "pocket" method of sowing cereals was compared with the ordinary drill, and both winter sown wheat and spring sown barley were experimented with. The

wheat plots were ruined by mice and other pests. The spring sown barley plots were on Field II, Coldharbour Loam, and they were sown on 13 March 1933.

*Results.*

Cwt. per acre.

| | Ordinary drill. | Pockets. | Significant difference. |
|---|---|---|---|
| Grain .. .. .. | 18·25 | 19·84 | |
| Total produce .. | 39·68 | 44·45 | 7·27 |

Thus there was no significant difference between the two methods. The stronger growth during the early stages of growth noticed last year on the "pocket" plots was not apparent this season.

PLACEMENT OF FERTILIZERS.

Four methods of applying fertilizers, which was the usual farm complete dressing, were tested:

1. Broadcast on the surface and raked in before drilling.
2. Sown with the seed.
3. Sown below the seed to a depth of about one inch.
4. Sown about one inch to the side of the seed.

*Results.*

*Field II (Coldharbour Loam).*

*Plots* 1/500 *acre, drilled* 14 *March* 1933.

Cwt. per acre.

| | Broadcast. | With seed. | Under seed. | Side of seed. | Significant difference. |
|---|---|---|---|---|---|
| Grain .. .. | 29·01 | 30·13 | 26·78 | 29·01 | 9·05 |
| Total produce .. | 61·38 | 69·19 | 65·84 | 64·73 | 7·02 |

The differences in grain yield are not significant; but there is a significant difference between the "total produce" on the plots which had the fertilizer placed with the seed as compared to the broadcast plots.

DRILL TESTS.

The critical studies of cereal drills, which were described in this *Journal* (No. 28, July 1931), established the fact that the force-feed type of drill was superior to the cup-feed as far as inter-coulter and per-foot performance was concerned; but the effects of the superiority on *yield* were not investigated at the time. We were able to conduct a properly designed experiment this year to examine this point. The Beaven Strip method was employed and three drills were tested:

1. An old cup-feed drill.
2. A new cup-feed drill.
3. A new force-feed drill.

The force-feed drill (Drill C in the paper referred to above) was not the one which had given the best performance in the original tests; nevertheless the "total produce" yield of barley sown by it on Field II on 23 March was significantly higher than that from the cup-feed machines:

*Results.*

Cwt. per acre.

| | Old cup-feed. | New cup-feed. | Force-feed. | Significant difference. |
|---|---|---|---|---|
| Grain .. .. | 39·35 | 38·86 | 41·09 | 4·26 |
| Total produce | 87·41 | 87·96 | 91·3 | 1·18 |

*Note.*—It will be seen that in all the above experiments a significant difference in "total produce" yield is not followed by a significant difference in "grain". The equipment available here for threshing small experimental plots is not satisfactory, and it is probable that the "grain" weights would not be quite the same as those recorded if more accurate machines were used.

## Spraying Machinery Investigation.

Good progress has been made in the critical examination of spray nozzles. A special apparatus has been designed and constructed by the department with which it is possible to obtain permanent records of the form of spray pattern made by any nozzle or setting thereof. With this apparatus we are able to obtain "stationary patterns", with exposures of 1/60 sec. upwards, as well as "traverse patterns", that is patterns made by a moving lance and nozzle, as actually occurs in the field. Over 300 of these patterns have been obtained from various commercial nozzles, and methods have been devised for analysing them. It is not yet desirable to form definite conclusions about types and settings of nozzles; but some points of practical importance have been disclosed by these tests. It is intended to study these further before results are published. For the accurate measurements of outputs we have constructed satisfactory instruments. An exhibit of some of the spray patterns obtained was staged at the Kent County Agricultural Show.

Observations of spraying machinery at work in the field, both on the College farm and elsewhere, have been made, and the writer visited the Colorado beetle areas at Gravesend and Tilbury to observe the machinery and methods employed to spray potatoes there. Both the Ministry of Agriculture officials in charge of the campaign and the firm which was doing the spraying gave us every assistance.

## Davies Compactometer.

Studies in soil consolidation and the penetrability of points continue. Several versions of this instrument, made by Messrs. A. Gallenkamp & Co. Ltd., have been tested and reported on, and it is understood that some other research stations are using the compactometer for some of their work.

DEMONSTRATIONS.

A demonstration of a new type of rotary tiller, manufactured in this country, was arranged. A Fordson tractor fitted with pneumatic tyres, and arranged to haul a potato sprayer, was tried to see to what extent such an outfit could be used without damaging the haulm. A demonstration of the transplanting machine, previously reported on by the department, which had been provided with an attachment for applying water to the roots of the plants being set, was attended.

ADVISORY WORK.

Advice on engineering matters has been given to farmers and others. A number of farmers and makers of machinery, in this country and abroad, have asked for advice concerning rotary tillage and mechanical details existing, or suggested in the designs of rotary tillers. Market gardeners, in the enquiries received, evince a great interest in transplanting machines, and a number have emphasized the relative unimportance of the purchase price if a thoroughly reliable machine is available with a satisfactory output. Questions concerning the possibilities of obtaining electric current for lighting and power purposes on farms through which high tension overhead cables pass have been dealt with, as well as other electrical problems.

## PUBLICATION.

DAVIES, C. 12 July 1933. Further Investigations into Penetrability of Steel Points and Soil Consolidation. *Jour. S.E. Agric. Coll.*, No. 32, pp. 84-94.

# DEPARTMENT OF ZOOLOGY AND GEOLOGY

By S. Graham Brade-Birks.

### Conference.

The Head of the Department represented the Principal at the opening of the Conference on "The National and Imperial Need for a Biological Outlook" organized by the British Social Hygiene Council on 30 November 1932.

### Board of the Faculty of Science.

The Head of the Department represented the Board of Studies in Agriculture on the Board of the Faculty of Science in the University throughout the session and attended all the meetings.

### Myriapoda.

A number of specimens of millipedes and centipedes were received for identification during the year. Mr. S. W. Rolfe continued his studies on Diplopoda and paid especial attention to *Ophyiulus pilosus* Newport.

### Soil Studies.

Mr. J. H. Mattinson, B.Sc., spent a few days in the Department to familiarize himself with the soil work in progress.

The publications of the Department are indicative of the work that has been carried out during the past session.

Mr. B. S. Furneaux, M.Sc., has again been engaged in survey work and this is fully reported by Dr. W. Goodwin in his account of the work in the Department of Advisory Chemistry.

Mr. J. Low, M.Sc., has continued his researches on the soils of Somersetshire and of the Wirral, and has made satisfactory progress. He has published a paper on Wirral Soils.

Dr. J. K. Dubey, before returning to India, did some very good work on the technique of making and keeping soil-monoliths and also completed a paper on local peat soils.

Mr. H. H. Glasscock continued his studies on soil minerals, and published a paper.

Dr. J. K. Dubey directed the studies of Mr. A. C. Procter concerning the hydrogen-ion concentration of the soils of the College Farm and they jointly published a paper on the subject.

The Romney Marsh Soil Committee has continued to meet under the chairmanship of the Head of the Department.

The Head of the Department lectured on the Natural History of the Soil to the East Kent Natural History Society at Canterbury and Dr. J. K. Dubey lectured at Southlands Grammar School, New Romney, on " What does your Soil tell you ? " before the Arts and Science Society and a number of visitors.

Dr. J. K. Dubey collaborated with Mr. B. S. Furneaux and Mr. R. M. Harrison where their work was related to the soils of Romney Marsh.

Dr. Brade-Birks visited Surrey in June to study soils with Mr. J. H. Mattinson, B.Sc.

### Agricultural Show.

Our exhibit of soils at the Agricultural Show at Maidstone was prepared and staged by Dr. J. K. Dubey.

### Editorial Work.

The Head of the Department again acted as Editor of the College *Journal* in January and July 1933.

## PUBLICATIONS.


Brade-Birks, H. K. and S. G. Feb. 1933. Notes on Myriapoda XXXIV, A rare English centipede, *Lithobius borealis* Meinert. *Ann. Mag. Nat. Hist.* ser. 10, **11,** 228-31.

Brade-Birks, S. G. 12 July 1933. A defence of the *soil-series* and American methods of soil-classification. *Jour. S.E. Agric. Coll.*, No. 32, pp. 229-31.

Brade-Birks, S. G., and Dubey, J. K. 12 July 1933. Soil Monoliths. *Jour. S.E. Agric. Coll.*, No. 32, pp. 162-7.

Dubey, J. K. May 1933. Soil Profile Studies of Romney Marsh Pastures. *Jour. Min. Agric.*, 40, pp. 131-40.

Dubey, J. K. Soil-profile Studies of Peat Pastures at Naccolt, near Wye, Kent, 12 July 1933. *Jour. S.E. Agric. Coll.*, No. 32, pp. 182-8.

Dubey, J. K., and Procter, A. C. 12 July 1933. An examination of the Hydrogen-ion concentration of the soils of the Farm of the South-Eastern Agricultural College. *Jour. S.E. Agric. Coll.*, No. 32, pp. 159-61.

Furneaux, B. S. 12 July 1933. The Field Examination of the Natural Drainage of Soils. *Jour. S.E. Agric. Coll.*, No. 32, pp. 219-26.

Glasscock, H. H. 12 July 1933. Some detritals of the Gault. *Jour. S.E. Agric. Coll.*, No. 32, pp. 227-8.

Low, A. James. 12 July 1933. A study of North-West Cheshire (*Wirral*) Soils. *Jour. S.E. Agric. Coll.*, No. 32, pp. 142-53.

# DEPARTMENT OF CHEMISTRY

By S. D. F. HARWOOD, L. W. L. COLE and I. B. PROWSE.

DURING the year ending 30 September 1933, 1,571 samples of Soils, Fertilizers, Feeding Stuffs and Milk, etc., were analysed.

FERTILIZERS.

Several samples of dried and undried *Poultry Manure* have been received and merit some comment. Their analytical data are summarized below:

| Sample No. | Physical Condition. | Nitrogen (Total). | Total Phosphoric Acid ($P_2O_5$). | Potash ($K_2O$). |
|---|---|---|---|---|
| 1 | Moist. | 1·75 | 1·52 | 0·65 |
| 2 | Moist. | 2·10 | 1·53 | -- |
| 3 | Semi-dried, unground | 2·69 | 1·54 | 1·29 |
| 4 | Semi-dried, unground. | 2·90 | 3·26 | 1·75 |
| 5 | Dried and ground. | 3·94 | 2·43 | 1·71 |

The figures above are given as percentages of the material as received.

The manure is obviously of very variable composition. Kiln drying is seldom carried out and protracted air drying nearly always results in the loss of a large part of the nitrogen, the most valuable ingredient. As a result all types of the material are offered for sale, from the wet, fermenting, fresh material, which is unsuitable for transporting any long distance, to the dried and ground or unground sample, which varies considerably in composition according to its method of preparation. Of the samples quoted, No. 1 was being sold to market gardeners at £1 per ton; on a unit value basis it was worth about 15s. Sample No. 4 was being sold at 10s. per ton; it was worth about 29s. Sample No. 5 had a limited sale at £3 10s. per ton; it was actually worth about 31s. The evidence of the availability of the nitrogen, phosphoric acid and potash in this fertilizer is conflicting but it seems probable that by comparison with other organic fertilizers of similar composition poultry manure should have a market value greater than the figure calculated on a unit value basis. The figures given indicate quite plainly, however, that an analysis is desirable before this material is purchased.

FEEDING STUFFS.

All the feeding stuffs received were satisfactory. Several excellent samples of tare and oat *Silage* were examined, one having a starch equivalent (net digestible energy) of 19·3 compared with the average figure of 13.

An inquiry was received from the Romney Marsh area concerning the relative feeding values of *Bean* varieties. It appears that a popular preference exists in the area for Long Pod beans rather than Mazagan beans for feeding to in-lamb ewes. No

information regarding the feeding value of varieties of beans appeared to be available and samples of Windsor, Long Pod, Mazagan and Tick beans were obtained for analysis. The starch equivalent was found to be practically the same for each variety, although there was an appreciable difference in the protein content. The figures are given below:

| Variety. | Protein (per cent.). | (Production S.E.) Net Digestible Energy. |
|---|---|---|
| Windsor. | 24·8 | 70·4 |
| Long Pod. | 27·9 | 69·8 |
| Mazagan. | 24·3 | 71·1 |
| Tick. | 20·3 | 71·0 |

The probable reason for the popularity of the Long Pod compared with the Mazagan is that the Long Pod beans are large and can therefore be thrown whole on to the grass without the necessity of using sheep troughs.* The order of size (and weight) is (1) Long Pod, (2) Windsor, (3) Magazan, (4) Tick, the last named being the smallest.

RESEARCH.

*I. Co-operative Work on Soil Analysis Methods.*

Mr. Cole has been engaged since 1931 in carrying out a series of analyses upon seven standard soils under a co-operative scheme devised by the Chemistry Committee of the Agricultural Education Association. The soils were distributed from Aberdeen, Bangor, Harper Adams, Rothamsted and Armstrong College, and the analyses agreed upon were:

(1) Carbon and nitrogen by the Bangor method.

(2) Hydrogen ion concentration (pH) by the quinhydrone method.

(3) Exchangeable potash as extracted by acetic acid and determined by a cobaltinitrite method based upon the well-known method due to Milne.

Seven centres participated in the scheme and as a result of the work to date the quinhydrone method for pH has been found to give concordant results for different workers, using the technique laid down by the International Society of Soil Science, 1930 Committee, and this technique has now been adopted for the quinhydrone method in this country. The work upon carbon and nitrogen estimation by the Bangor method and exchangeable potash determination is still proceeding. The results obtained in 1931 were not too encouraging as regards uniformity, but a more rigid standardization of the technique has led to much more satisfactory agreement being obtained. A full account of the work will appear in due course in *Agricultural Progress.*

*II. Fertilizer Experiments in Romney Marsh.*

Published accounts of fertilizer trials are not ordinarily accompanied by an exact pedological description of the soil on which the trial was carried out. In the absence of such a description, the results obtained for any one crop to a large extent apply only

* This suggestion is due to Mr. Garrad, the County Agricultural Organizer.

when it is grown again in the same field. The conclusions drawn from the trial do not necessarily apply to the crop when grown elsewhere, since there is no evidence that soils of other fields are pedologically similar to the soil of the trials.

The statement that a fertilizer trial has been carried out on a soil belonging to a certain soil series implies that a pedological description of the soil exists and has been recorded. It remains to be shown that all examples of soil belonging to any given series, wherever situated, will respond similarly to the same manurial treatment. If this assumption is correct, the results of fertilizer trials on such an example of a named series will have a much wider application than if the full soil description is unknown.

It was to test this question of similar manurial "response" by soils belonging to the same series that the experiments in the Marsh were undertaken during the season 1932-33. The work carried out in the area by Mr. Cole (published conjointly with Dr. J. K. Dubey, this Journal, No. 30, July 1933) resulted in nine well-defined soil series being established. Probably the most important arable soil in the Marsh belongs to the Newchurch series and six examples of soil of this series were selected, five in the Marsh and one, outside the area, at Woodchurch. Winter wheat had been sown in October 1932 in these fields and one one-acre plot in each field was dressed with 3 cwt. of superphosphate. In addition, a 4×4 Latin Square was laid down on one of the fields, giving a variety of treatments designed to determine the effects due to three different nitrogenous fertilizers, with and without additional phosphorus and/or potassium.

All the manures were sown in February 1933 and all the plots were harvested early in August 1933. The results will be published in a future issue of this *Journal.*

*III. Soils of Pevensey Marshes.*

In line with the work upon the classification of the soils of Romney Marsh referred to above a similar survey of soils of the Pevensey Levels has been undertaken by Mr. Prowse. The interest attaching to this investigation lies in the similarity of origin and mode of formation of these two tracts of alluvial land, although factors of drainage and climate have resulted in the systems of farming in the two areas being quite distinct.

*IV. Mushroom Growing Experiments.*

Under the direction of Mr. Cole, Messrs. R. T. Bather and P. I. Turner have tried out artificial farmyard manure and cow dung as substitutes for horse manure in mushroom growing with some success. The experiments are being continued.

*V. Feeding Value of Hay.*

An investigation into the feeding value of a number of samples of hay from all parts of Kent, Surrey and Sussex is being carried out by Mr. Prowse. It is hoped that an account of these results will shortly be published together with some notes on the factors influencing the quality of the hays examined and on any noticeable reaction of the stock to which they were fed.

# INDEX

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COUNTY COUNCILS OF KENT AND SURREY

# THE JOURNAL

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## WYE, KENT

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* *Recognized Teacher of the University of London.* † *Appointed Teacher of the University of London.*

## CONTENTS

# EDITORIAL

ONCE again will be found in the pages of the *Journal of the South-Eastern Agricultural College* a wide range of papers of interest to the farmer and the horticulturist. These papers call perhaps for no other editorial comment, than that they are once again indicative of steady progress along many lines of research and are evidences of the service which the College as teacher, investigator and adviser is daily rendering to the community.

I am indebted to Mr. L. W. Cole for his kindness in preparing the useful index to the present issue of the *Journal.*

S. GRAHAM BRADE-BIRKS.

# RESEARCH IN AGRICULTURAL ECONOMICS: A TEN YEARS' RETROSPECT

By JAMES WYLLIE,
*Department of Economics.*

THE Department of Economics in this College was established in 1923 and investigational work was commenced at Michaelmas of that year. It has therefore completed its first decade of active service and this may be taken as a fitting opportunity to discuss in very general terms, first, the main objectives of the work which has been taken in hand, and, second, some of the impressions which have so far been formed regarding research work in the field of agricultural economics. For there can be no doubt that there still exists a large amount of haziness and uncertainty as to what "agricultural economics" is and as to what an "agricultural economist" professes to be. But first a few words about "economics", without any qualifying prefix, because many of the popular misconceptions about agricultural economics have their roots in mistaken ideas of the meaning and scope of economics.

Economics is of course a word which is on everybody's lips and pen these days: we talk and write about economic mycology and economic nationalism, economic wages and economic outlooks, economic efficiency and economic psychology or we content ourselves by just saying that "it isn't economic", but how many people who use the term have any clear conception of what it means *to the economist?* And this widespread misunderstanding of what economics really is probably goes far to explain the mildly contemptuous attitude which many quite intelligent people have towards economics and economists. Our chemists and our physicists, our engineers, our doctors and even our philosophers command respect and admiration for the mighty things which they have done but our economists stand condemned, not indeed because they are held *entirely* responsible for the so-called economic disorders from which the whole world is still acutely suffering, but because they have not been able to discover an effective remedy!

Now if we would seek to know just what economics is, just what duties the economist takes upon himself, we shall turn, not to the geologist or zoologist, nor yet to the politician or social reformer, but—to the economist himself. And what will he tell us? First, he will emphasize that economics is in fact only a part, and not even the most important part, of that immense subject—the study of man in all his various relationships—which is commonly called *Sociology*. It does not profess to tell men what they ought or ought not to do according to recognized moral principles, nor what they may or may not do according to the laws of their country, nor yet what views they should or should not hold as to the method by which their country should be governed. It is, in short, primarily concerned with man's *business* relationships—how he earns his money and how he spends it. It is true, of course, that only somewhat arbitrary lines can be drawn between these various divisions of Sociology; it is equally true that, as a good citizen, the economist may hold quite strong views on ethical, legal and political problems. The plain fact is—and no one knows it any better than the economist—the plain fact is that few, if any, of the major problems with which civilization is presently struggling can be resolved on purely economic grounds. Such problems are in part economic but they are also, and to a much

greater extent, ethical and political, especially perhaps political. How then can we expect them to be solved by the economist, as economist? Although there are many who will sneer at the very idea, can it be denied that if only man, every man, were "to love his neighbour as himself", there would be far less need for him to worry about exacting his just legal rights, far less difficulty in satisfying his reasonable economic wants?

In the second place, the economist will tell us that he is primarily concerned with the analysis of man's business relationships *as they are* and not as he thinks they should be, to explain *why* the level of wages is what it is and not to say what it ought to be, to explain *how* the monetary machine works rather than to say what kind of monetary machine ought to be worked. Accurate diagnosis of the causes of our present troubles in the business world is most essential if permanent cures are to be effected and there is already a large measure of agreement amongst economists as to *some* of the most important causes, the differences that arise about the best possible treatment being due to a considerable extent to differences on the ethical and political aspects of the problems. During recent years, economists have taken a prominent part in putting forward recovery and reconstruction plans but in formulating these plans they have become, for the nonce, philosophers, psychologists and politicians, in addition to being merely economists. The idea that our chief problems to-day are entirely economic in character and can be solved on purely economic grounds is wholly fallacious but this is no reason why economists should not *contribute* to their solution.

In the third place, the economist will emphasize that he is primarily concerned with the *social* aspects of business transactions. The individual not unnaturally is always asking himself: How will this or that affect me, will it help me or hurt me? but what may be good for the individual is not necessarily "economic", that is, it may not always be good from the social point of view, from the point of view of the community as a whole. This is far from saying that the economist is not interested in individuals of all kinds. The "dismal science" of the classical school of English economists earned its title partly because these economists created an "abstract" or "economic" man who was supposed to obey economic motives and economic motives only. But the modern economist deals with men just as he finds them, men who are imbued with motives of love and hate, fear, patriotism, philanthropy and what not, as well as with purely economic motives.

Finally, the economist would probably point out that inasmuch as economics is engaged primarily in searching out the whys and the wherefores of man's business relationships it has just as much right to be called a science as chemistry, physiology, mycology or any other of the physical or biological sciences. And he would probably also suggest that it is more than time that economics received at least as much attention in our schools and colleges as is given to these other sciences. But a pre-requisite to the adequate recognition of economic science in our curricula is a proper appreciation of what the science actually is and, perhaps more especially, is not.

And now a word or two about the *agricultural* economist. First and foremost, the agricultural economist should be an economist, and so all that has just been said applies equally to him and to any other economist. The agricultural economist is not, as many people seem to imagine, a sort of glorified accountant. He may and often does use accounting as *one* of the tools of his trade, but the notion that he is concerned *only* with determining profits and losses, costs and prices, capitals and turnovers, is completely erroneous. Nor is the agricultural economist in any true sense a statistician. I once read a rather lengthy paper on "Some Economic Aspects of Milk Production"

in which not more than about a dozen figures were used. One critic remarked on this and asked me : " But where does the economics come in ? " The economist may or may not use statistics of various kinds *to illustrate the general principles* which he is enunciating but, if they are sound, it should be possible to understand these principles—or many of them at least—in the light of cold and calculated reasoning and without the doubtful aid—in many cases at least—of masses of highly indigestible figures. It may or may not be true that figures cannot lie but is it or is it not true that liars can figure ! It may or may not be true, as a very eminent politician recently told us, that there is no time for principles these days but it is unquestionably true that our present troubles are largely due to the open-eyed neglect of sound principles—in ethics, in politics and in economics.

Nevertheless, it has to be admitted that there is still some difference of opinion amongst agricultural economists themselves, not only as to the scope of the subject but also as regards the best methods by which economic researches should be conducted. There is still some doubt as to the boundaries between the fields of the economic agriculturist and the agricultural economist. For example, is it the duty of the agriculturist or of the economist to conduct experiments into the law of diminishing returns in agriculture or should they be conducted jointly ? Would the conclusions from the famous Cockle Park experiments not have been less open to criticism if an economist had been given some say in planning the experiments and in interpreting the results ? In an investigation conducted with a view to finding improved methods of milk production what part should be played by the economic agriculturist and by the agricultural economist respectively ? It is necessary only to ask such questions to realize that under existing conditions in the world of agricultural education and research the economist lives and works in constant danger of being charged with jumping someone else's claim ! Because the economic agriculturist has existed, in some form or other, at least from the time of the Pharaohs whereas the agricultural economist appeared on the scene only yesterday.

As regards the methods of research, little need be said here. This is, of course, the age of " standardization " : what is not standardized must be inefficient and uneconomic ! And so it is no wonder that agricultural economists are always being urged to get together and " standardize " their methods of working. But so long as there is so much genuine difference of opinion—or shall we just say ignorance ?—as to what are the *best* methods of research is it not rather futile to talk about standardizing them ? It may be right to introduce compulsory co-operation into agricultural marketing but compulsory co-operation in agricultural research is surely unthinkable. And yet that is what standardization of methods implies, so long as there is so little evidence to show what is and what is not a suitable method of investigation for any particular problem.

It may, however, be worth while pointing out one fundamental difference between research work in agricultural economics and in other branches of agricultural science. In the latter, work in the laboratory is combined with carefully *controlled* field experiments : indeed, an elaborate technique for the accurate interpretation of all kinds of such experiments has now been evolved. But the economist on the other hand must deal in the main with *human beings*—landowners, farmers and farm workers—and it is only very occasionally that he can adopt the method of experimentation. He must take farms as he finds them and where he finds them. Hence, although it may be hard enough to discover " the facts of the case " it is a far harder thing to *interpret* these " facts " correctly. It is this difficulty in interpretation which makes economic research so exciting. For example, a farmer may make an important change in the organization of his farm and the results of that change may be very carefully and very fully recorded. But

unfortunately there is no " check plot " and so in trying to measure the net results of the change one must try to estimate (or imagine or guess) what they *would* have been if no such change had been made : a method of comparison which is unknown to the chemist, mycologist or geneticist. Now let us return home and try to stay there for the remainder of this article.

When this department was established in 1923, the writer was given literally a free hand to make or to mar its fortunes. The first six months were spent in spying out the land, in making contacts with the county agricultural organizers and through their good offices with farmers in different parts of the province, as well as in preparing the forms to be used in the investigational work in mind. At Michaelmas 1923 an " Investigation into Farming Costs of Production and Financial Results " was commenced—an investigation which obviously need *never* end ! Up to the present date, eighteen reports, extending to some 540 pages have been published, dealing not only with the results obtained but also, in some detail, with the methods by which they have been obtained. More recently, schemes for food-recording for both cows and pigs have been introduced while investigations have been commenced into the economics of strawberry and canning-pea production. A report on three years' results from the food-recording scheme for cows has been published and has been in exceptionally good demand. Nor must it be overlooked that the department is responsible for the teaching of agricultural economics to all degree, diploma and certificate students.

The general objective of all these investigations can be very briefly stated. It is to try *to discover methods by which the efficiency of farm management can be improved.* Until recently, it was apparently assumed that efficiency in management was a matter of judicious manuring and feeding, the selection of suitable varieties of crops, the grading up of the herds and flocks, the use of up-to-date machinery and so on ; but it is now generally recognized that it is possible to be highly efficient at all these things and yet be a somewhat inefficient manager. Now it is easy to compare different methods of manuring and feeding, it is a simple matter—on paper at least—to make a 600-gallon herd into a 900-gallon one, but it is a very difficult matter to compare the efficiency of different managements. If every farm was the same size, had the same kind of soil, the same climatic conditions, the same marketing opportunities and so on, then of course managerial efficiency could be very easily and directly measured by means of the profit and loss account. As things are in this country the profit and loss account is a rather flexible measuring stick of efficiency and must be used with the greatest circumspection. But since we cannot have the same kind of soil and climate and markets, in other words, since the manager has little or no control over many of the most important factors in farm management we must as far as possible try to *measure his efficiency by means of those factors over which he has at least a fair measure of control.* This principle lies at the very foundation of the work which has been going on during these last ten years. Because it is obvious that the improvement of managerial efficiency must remain rather a hit-or-miss business unless we have reliable methods of measuring at least certain aspects of it, if not all aspects.

Now a measuring stick is more than an idea : it is something concrete. And in the sphere of management the raw material of measuring sticks consists of *records* and then more records—using the term in the widest possible sense to include all kinds of written documents.* There is no magic way of measuring managerial efficiency ;

* Amongst the most important of these " management records " are : labour and tractor records ; records of consumption of foodstuffs, manures and stores ; threshing records ; yield records ; milk, egg, pig and lamb records ; pedigree records and financial records of all kinds.

indeed, the more one knows about it the more reluctant one becomes to offer any sort of opinion, without records. Of course, many people will not agree: they think they know a good farmer when they see one! Let such people remember what happened when milk-recording was introduced. Before, the farmer was positive that he knew his best and his worst milking cows by observation and by an occasional check-up on the milk pail; after, he had to confess that his previous conclusions were oft-times hopelessly wrong. Milk-recording is the measuring stick of milk production and there is *no other* measuring stick that is worth thinking about.

Now let us consider for a little this matter of keeping records. It will be said that farmers have a particular aversion to keeping any kind of records, that even if they liked doing so—in which case they would indeed be very exceptional!—they are too busy in the daytime and too sleepy in the evening to do it. I have dealt with this question at some length elsewhere*; here it may be sufficient to say that the real reasons for the farmer's antipathy to record keeping are, first, that little attempt has been made to show him what records to keep, and second, practically no attempt has been made to demonstrate that record keeping has a definite cash value. This question of the *utility* of record keeping is of paramount importance and deserves very careful consideration; everything in fact turns on it, because the keeping of records is not an end in itself but only a means to an end.

Let me try to illustrate what I mean. Farmers are charged with being very bad account keepers and the charge is no doubt well-founded. But were I a farmer I should in turn charge my advisers with recommending a method of accounting which would be of practically no value to me as a manager; I should say most emphatically that there is no special virtue in account keeping *unless* it can give me some sure guidance towards better methods of running my farm. And this counter-charge would be equally well-founded! Ordinary accounts are interesting historically and academically, they may even have some slight value politically (but *only* in times of stress), but from the point of view of better management they are of very limited value indeed. The best that can be said of ordinary " simple " accounts, such as farmers are almost invariably advised to keep, is that they provide *a necessary foundation* for a system of accounting which would be of definite help to the management. [The relation of account keeping to income tax assessment does not come within the scope of this article: in any case, only a small minority of farmers are concerned with this aspect of accounting.]

Now it is the very definite experience of this department that provided farmers can obtain a set of accounts which will explain some of the hows and whys and wherefores of the year's net financial results they will take a surprising amount of trouble in keeping the necessary records. That at least is not theory but hard fact. It may well be of course that they cannot prepare the accounts themselves and require expert assistance but that is not the point. The point is that it is commonly maintained that they will not keep records because they are too lazy, or too busy, or merely that they are incapable of doing so, whereas by far the most important reason is that they have never been shown how the records could be made really *useful*. And it is no disgrace to farmers if they are not able to prepare the kind of accounts which they want to have. Do the so-called " business men ", with whom the farmer is always being unfavourably contrasted, prepare their accounts themselves? Of course not.

But we can carry the argument a step further. In the keeping of management records on the farm, the co-operation of the *farm workers* is essential for smooth working,

* The " Use and Abuse of Farming Records "—*Jour. Yorks. Agric. Soc.*, 1934.

as well as for accuracy. Farmers will try to maintain that their workers are not capable of filling in a weekly time or labour sheet or that they cannot be trusted to make even the simplest record of foodstuffs used by the stock, paraffin consumed by the tractor, manures applied and so on. Again, actual experience shows beyond any doubt that given the right spirit, along with a little patience during the period of "learning", the majority of farm workers are not only perfectly able but also perfectly willing to co-operate in keeping these various records. It has been already said that economic research must take account of human beings and any method of research which leaves out of account the farm worker and the part which he can play towards higher all-round managerial efficiency is overlooking one of the most vital factors in the case.

It can be said therefore that the work is of a truly co-operative nature: it involves the closest possible co-operation of farmers and, through them, of farm workers as well. And it is based upon the keeping of management records being regarded as an integral part of the daily and weekly routine, in which respect it differs fundamentally from another common method of investigation in which a hurried visit is paid once a year to a large number of farmers but no attempt is made to "interfere" in any way with the "normal" routine of farm affairs—a method which is popular because it asks the farmer merely to *talk* for an hour or two, does not even ask him to sign his name on the dotted line, and ignores the farm workers altogether.

But there are still many farmers who remain unconvinced as to the need for more detailed accounts, based upon management records. They are satisfied that they already know why profits are as low (or losses as high) as they are, according to their "simple" accounts. On the contrary, one of the most valuable lessons of these investigations is that the farmer's general impressions about the relative profit-earning (or loss-making) capacity of the different enterprises are in most cases extremely unreliable. Again and again when a farmer has seen the results of the detailed accounts his first reaction has been one of surprise—surprise that "this" has not done as well as he expected, that "that" has done better, and so on. And then his scepticism is fully aroused! He begins to doubt whether the results are after all "correct". If he thinks that sheep have been paying well whereas the accounts show that they have been hardly paying at all then he thinks there must be "something wrong"—not with his *estimate* of how sheep have paid, oh, no! but with the *actual result* as shown by the detailed information of purchases and sales, wages, foodstuffs, valuations, etc., which he himself has provided and which has been checked up in the various ways known to investigators.

And even if after the closest possible scrutiny of the detailed accounts he is forced to admit that the accounts "appear to be all right"—this is perhaps about as far as he will ever go!—and that his impressions "appear to be wrong", he will probably fall back upon the contention that it is impossible to split up the ordinary farm into a number of self-contained "departments", as is apparently done in the detailed accounts. Now whether or not this contention is sound does not much matter from the point of view of this article. The *first* object of management records and detailed accounts is *not* to tell the farmer just what crops to grow and what livestock to keep so that he will be sure of making the maximum profits but to try to explain why certain crops and certain livestock have done as well or as badly as they have done. Take for example Sheep. Report No. X shows that the financial results from sheep, especially on arable land, were much less satisfactory than they were commonly thought to be. The first criticism of this result generally was that the sheep had been charged too much for the folded crops—such as swedes, turnips, rape, and sugar-beet tops—whereas the accounts showed quite clearly that in many cases the sheep would still have lost money even if they had got the

folded crops for *nothing*. But space permits no more than the emphatic statement that time and again even highly experienced farmers are " surprised " at the results shown by the detailed accounts and this is merely another way of saying that their own diagnosis of " the trouble " was wrong and that therefore their remedial measures would very probably be more or less useless.

It follows from this that advice on farm-management problems which is based only upon observation and experience is likely to be of rather doubtful efficacy. Fortunately, the adviser is fairly safe because only detailed accounts can show the actual results obtained from following the advice given.

The investigator who maintains that efficiency in farm management cannot be measured save by suitable records stands to be shot at from two sides. The great majority of farmers still think that it is impossible to compare managerial efficiency because of the enormous variations in the local conditions of soil, climate, markets, etc. Even the farmer who is regarded as being a rather indifferent manager will seek to explain away his unsatisfactory results on the basis of ill-luck, poor soil, bad weather and so on, and seldom, if ever, will he admit that he himself is partly, if not largely, responsible. Now it is clear that there are many quite important factors in successful farming which *are* under the control of the farmer. The choice of varieties of seeds—cereals, roots, grasses, clovers, etc.—which are suitable to the natural conditions rests with the farmer but what is wanted to facilitate that choice is the systematic recording of the results obtained from different varieties over a large number of farms, as has been done for cereals in Essex. The choice of manures and of the quantities to be applied per acre is also quite open and it could be narrowed down very considerably if cropping results from different methods of manuring could be systematically recorded. This does not mean that we can ever hope to eliminate the need for judgement and common sense in seeding and manuring, because for one thing the weather conditions of the growing season which *follows* seeding and manuring cannot be predicted with any assurance of accuracy. Again, the dairy farmer cannot control either the prices of purchased cakes and meals or the production costs of hay, roots, etc., but he can control to a very large extent the kinds and quantities of the foodstuffs which he uses for his dairy stock. Without suitable records, however, he can never be sure whether the quantities consumed are in economic relation to the amount of milk produced.

On the other hand, progressive dairy farmers are now firm believers in the utility of milk-recording while poultry farmers are quite confident of the value of egg-recording. Pig-keepers are also beginning to realize that pig-recording would be a considerable help towards more economic pig production. I am not concerned here with the differences of opinion as to how recording can *best* be conducted and as to the dangers in indiscriminate comparisons ; the first thing is to get the principle of recording widely accepted, to get farmers (and others) to realize that management records, of whatever kind, have a real cash value.

But the case for management records and detailed accounts has also to meet assault from another quarter. Some economic investigators still maintain that advice on all important farm management problems on the individual farm can be quite surely based upon nothing more than simple financial accounts, although confidence in this basis would appear to be gradually weakening. At one time, the writer was of this opinion himself but experience teaches even economists ! To illustrate, let me quote just one case. The farmer was quite firmly of the opinion that sheep were " doing " very well and that, on the other hand, cows were just holding their own. The ordinary financial

accounts left him not a bit the wiser but the detailed accounts showed that the true position was just the opposite from what he thought it was. Now it is hard to see how a definitely wrong diagnosis can be expected to result in the right treatment being prescribed. That at least is not the method of the scientist and the mere fact that the quack sometimes effects cures is no reason for supporting his methods.

Now consider another aspect of economic research in agriculture. Like my colleagues, I am called an " advisory " agricultural economist and it may be worth while asking just what the term means in this particular connexion. Farmers are perhaps to be excused if they think that it is the job of the advisory economist to advise them what they should do in order to obtain the highest possible profits and there is certainly a widespread impression that the economist must be held responsible for advising the industry as a whole what steps it should take to strengthen its financial position. Just how many farmers would be willing to follow the advice of even the most reputable economist is rather a moot point and the writer at least cannot even imagine any body of economists receiving full powers to reorganize the agricultural industry on what *they* considered to be the best possible basis.

But as already indicated the first duty of the economist is not to advise farmers what *to do* but rather to advise them what they *have done*,* to make as accurate and as complete a financial diagnosis as possible of what has happened over a given period of time. For example, a farmer sells 20,000 gallons of milk in a year. Does he know what has happened in the process ? In general terms, yes ; in economic terms, no ; except in those few cases where management records and detailed accounts are kept. The economic researcher must take the process of milk production to pieces, he must study each piece both separately and in relation to all the other pieces in order to discover just what has taken place. And there is no other way towards an accurate economic description of the process of milk production.

Economic research, however, is or should be also of very definite interest and value to the various county agricultural staffs, as well as to teachers of agriculture in our schools and colleges. Neither of these classes is usually in a position to carry out detailed economic investigations and they must therefore look to the economist to provide them with the raw material which will assist them in forming sound economic judgements on the problems brought before them. Indeed, it may be strongly suggested that *one* of the measuring sticks of the efficacy of economic researches is the extent to which they satisfy the requirements of the two classes just mentioned.

It would appear that the work of the advisory economist would be seen in a much fairer light if only farmers and others would regard it from the above point of view, if only they would realize what economics is and what it is not. But this is far from saying that the economist must ever refrain from offering advice. Far from it, but his advice must be of a rather different character from that given by other scientific workers on such matters as manuring, feeding, spraying, and so on. Take two examples. A farmer asks the county agricultural organizer for advice on how to manure his potatoes and on what varieties to grow. He gets quite definite answers. [It is not suggested that such advice is infallible, merely that it is definite.] The same farmer asks an economist about the advisability of including potatoes in the rotation and to what extent and he may get an answer similar to the one actually given in a certain case, as follows : " The average cost per ton of ware (and seed size) over the 1927 to 1932 crops was within

* The " advice-note " merely advises the receiver that the sender has done something—forwarded the goods, etc.

a shilling or so of £5 per ton. . . . It is quite clear that the chances of making a reasonable profit, taking one year with another, at a cost of £5 per ton are somewhat remote. Clearly, the soil and climatic conditions have not been at all favourable to economic potato-growing and the evidence is sure that some change must be made somewhere in the method of production with a view to lower costs per ton." It may be added that in this case at least the farmer fully agreed with the conclusion but did *not* expect the economist to tell him how to grow potatoes at a profit !

Again, a farmer asks the agricultural organizer about the feeding of his cows and receives definite advice to feed such and such a ration, coupled, it may be, with a warning that *any* alteration of the ration by the farmer may render it unsuitable. Then he asks an economist about the general economy of milk production, whether his costs are as low as they should be and if not what changes should be made. After due investigation, which may involve quite a lot of work on the *farmer's* part, the economist may demonstrate that the farmer is using a much larger quantity of food nutrients per gallon of milk than other farmers are using. Whereupon, he may " advise " the farmer what these other farmers have done and are doing in order to minimize the consumption of foodstuffs in relation to the milk produced. It is no fault of the economist if the farmer persists in his old ways : he has done all he can be expected to do when he has exposed the leakage and the stopping of the leak is entirely a matter for the farmer. [Of course, the leakage may be elsewhere than in feeding but the same principle applies right through the process of milk production.]

Now the charge that is often made against the economist is that he always leaves the decision to be made by the farmer, whereas the agricultural organizer more often than not gives definite prescriptions which he expects to be taken without any adulteration with the farmer's own ideas. Nevertheless, this economist at least will continue to leave the farmer to make the final decision ; he will do everything possible to " advise " the farmer as to the various factors that must be considered in coming to a decision ; he will continue to urge farmers to set about keeping management records by which these facts can be laid bare for their consideration ; but he will not hesitate from advising farmers that they must continue to assume the full responsibility of managership on their farms.

And, of course, exactly the same principle applies to the industry in general. The first duty of the economist is to discover *what is*, to dissect the industry in such a way as to expose its strong and its weak points ; as soon as he begins to indulge in discussions as to what *should be* in the industry then he takes on the role of politician, philosopher, and psychologist, as well as that of economist. This does not mean that he should never do so ; merely that if he does his plans cannot be criticized entirely on economic grounds.

Yet another aspect of this kind of work calls for attention. It has been said that the ultimate objective is the grading-up of managerial capacity and an important part of this process consists of the elimination of waste of all kinds, whether of time or material or temper. It is not sufficient merely to wait until the end of the year and then present the farmer with a sort of " bill of costs " for the leakages which have apparently been going on : it is necessary to show him what steps he can take to *prevent* such leakages. For example, in the food-recording scheme for cows one of the chief objects is to check the uneconomic use of foodstuffs of all kinds but especially of the more expensive cakes and meals. Now if at the end of the year we find a discrepancy of, say twenty per cent., that is, if we find that for every five tons of cakes and meals which the farmer thought he was using six tons were actually used, that may be a fine subject for a big headline

but the *desired* result is no discrepancy at all (beyond what cannot be avoided in the "retailing" of bulk quantities of any material). It is a curious fact that depression is always a more arresting condition than prosperity, unemployment than employment but surely it is prosperity and employment that we want, even though it does lead to a shortage of sensational headlines. And in the same way the economic investigator should feel a far greater glow of satisfaction when he finds that he has done something to put things *right* than when he finds that a two or three page " report " is necessary to tell the farmer all the things which he thinks are *wrong*. It may be added that one of the chief functions of the detailed investigation is to discover the various points in the management at which leakages are going on. And there is *no other way* by which they can be discovered.

One last point. Owing to the intensive methods adopted it is possible to deal with only a limited number of farms—twenty to twenty-five in the detailed investigation, thirty to forty in the food-recording schemes and in the special " enterprise " investigations—and it has been suggested that this concentration of effort cannot be justified, that the results obtained are applicable, and of interest, only to the particular farms and farmers from which they have been obtained. In part, this criticism is based upon the modern craze for doing things " on a big scale "—even quite ordinary people talk quite glibly in millions ! But it is perhaps mainly due to a complete misunderstanding of the objectives. If the principal objective was to discover the profitability of different systems of farming, to determine the "average" cost per quarter of wheat or per gallon of milk throughout the College Province then obviously the criticism would be well founded. But in fact so far from being the principal objective it is not an objective at all. It is hardly worth while explaining why this is so ; it is more important to emphasize that many of the lessons that can be drawn from the small number of farms under investigation are undoubtedly applicable to the great majority of farms. This does not mean, for example, that Black should have the same production cost per gallon for milk as White ; it does mean that if White has reduced his feeding costs per gallon by the systematic recording of the foodstuffs consumed there is no valid reason why Black should not go and do likewise. And if Brown runs a tractor at a cost of 1s. 4d. per working hour there is surely something wrong if Green, with similar conditions, has one of 3s. per hour.

We hear a great deal these days about better marketing ; very little about better management. It is my firm conviction that the key to better management consists of management records and detailed accounts. A young farmer who could start off with suitable records and accounts would gain more real "experience" of farming in five years' time than he would gain in twenty or thirty years without them. I am not altogether without hope that one of these days farmers will come to realize that marketing schemes, no matter how efficient they may be, are no substitute for efficiency in production. It is no answer to say that farmers cannot themselves be expected to keep detailed accounts. They buy manures and foodstuffs, they pay for the use of their land and for the labour expended on it : why ? Surely because all these things are necessary. Why then are they not prepared to pay for the services of an accountant ? Because up till now they have never considered that ordinary accounting, income tax apart, was worth paying for. The results obtained during this ten years' work have clearly demonstrated that the keeping of records and detailed accounts is worthy of a regular place in the routine of the ordinary rent-paying farm and plays an essential part in efficient up-to-date management.

# RATE OF TURNOVER AS A FACTOR INFLUENCING FARM PROFITS

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In the last issue of the *Journal* a brief analysis was made of cost per unit as a measure of efficiency, and now it may be interesting to consider rate of turnover of capital as a factor influencing farm profits. It is common for comparative purposes to express the annual value of the gross output of the farm as a percentage of the capital employed and such a figure indicates the degree to which capital is being turned over annually; this is, more briefly, the " rate of turnover ".

As has been pointed out so often, Agriculture is characterized by having a relatively low rate of turnover, many of its main products taking considerably more than a full year to prepare for harvest and market. This fact alone links turnover with profits and in times of uncertain price movements it might be expected that farms with relatively high turnovers would be less influenced by changes in relative price levels. The rate at which capital can be turned over is, however, often regarded as one of the chief factors influencing *individual* farm profits and it is interesting to examine it in that light.

The difficulty of determining exactly what the capital and the gross output have been during the year on the ordinary farm makes comparisons based on calculations of the annual turnover somewhat uncertain. Apart from this, however, the presumption that a higher rate of turnover will indicate a higher level of profit depends on several assumptions, of which perhaps the truest is that the same rate of total profit can be secured by taking less profit per unit of output.

If a turnover of 80 per cent shows a profit of £5 per cent on capital, the profit is £1 on every £16 worth of goods sold. To show a profit of £5 per cent on a turnover of 60 per cent would, on the other hand, necessitate a profit of £1 on every £12 worth of goods sold. At first glance it might appear that the latter might be the stronger position, but since the essence of an open market is that in it all producers obtain the same price for the same goods it follows that it may be difficult to secure the " one in twelve " price in the face of competition from the producer who can afford to sell at the "one in sixteen " rate. In practice, one may assume that the second producer also will have to take the lower profit margin and sell £16 worth of goods to obtain a profit of £1. Such a sale means 25s. per cent less on his capital than the first producer, or £3¾ per cent as against £5 per cent and this *proportion* holds good for these two producers whatever the basic rate of profit is taken to be. Thus, if £1 profit per £20 worth of goods is sold be taken as the basis, the farm with a turnover of 100 would make 5 per cent profit on the capital, with a turnover of 80 the profit would be 4 per cent and with a turnover of 60 the profit would be 3 per cent.

We have presumed the goods produced in these cases to be similar and competing in the same free market, but what if they are totally different products—say wheat and milk? To a certain extent all the main agricultural products are competitive if a sufficient number of farmers are ready and able to turn from one to another according to the profits to be expected. This leads us to the second general assumption which

would be necessary if rate of turnover is to be closely associated with profits—that taking farming as a whole there will always be a strong enough and quick enough movement towards equalization of profits per £1 of *different* products sold. In other words, should £1 profit per £16 worth of milk sold be general, equally so will £1 profit per £16 of wheat sold.

That these long-range tendencies are not actually strong enough to allow for rate of turnover to be taken as a general factor influencing farm profits would seem to be borne out by the fact that although in some surveys covering a number of farms it can be shown that in general those with higher turnovers made higher profits (or lower losses), in others there is no such correlation. Where there is some measure of general correlation, analysis of the figures often shows that the higher rates of turnover were in general associated with particular groups of farms which in turn were producing particular products differing materially from those produced by the remainder.

To say in such cases that a high rate of turnover was a factor affecting profits may be merely another way of saying that *particular products* generally showed higher profits than others.

While one might possibly be justified in regarding the profits from these products as due to the fact that from their very nature they permit of a high rate of turnover, there is, on the other hand, no justification for presuming that had the remainder of the farms had as high turnovers *in their own lines of business* their profits would have been correspondingly greater.

Actually it may be supposed that turnover will reflect the same limitations imposed by the law of diminishing returns on the production of individual farm products. While increasing rates of turnover in individual cases may for a time give increased total profits in much the same way that for a time increasing " doses " of manures may give increased returns, turnover above a certain limit might be secured but only at a progressively decreasing margin of profit.

Further, to paraphrase Marshall, if the products are ones for which customers are more likely to be tempted by appearance than by low prices, producers will be able to obtain prices which give a comparatively high rate of profit per article on a comparatively small turnover ; but if not, they will be compelled to take low prices and try to force a relatively large business in proportion to their capital.

We need not be surprised, therefore, to find that in fact, and especially if the goods are in different categories altogether, profits of £1 in £12 worth of goods sold can persist although the general run of profits in another line is only £1 in £16 worth sold, and one must guard against thinking that the higher rate of profit per unit sold is a form of profiteering. One can safely say that if it really *was* easy to secure a high rate of turnover in producing the higher class article the price would fall to that of the ordinary article which it would shortly replace altogether. In many cases, of course, not only does the high class article *cost* more to produce, but in hard times, which it must not be forgotten fall on the producer through the consumer, it is often more difficult to find a sufficiently large market at a price which would allow of a high turnover.

It may be thought that the cost of securing any turnover has been referred to as though it were merely an incidental factor and one which could be ignored in relating rates of turnover and profits. Actually, of course, one may expect to find an enormous range of costs for the same turnover even where the goods produced are of the same

type. The only conceivable way of analysing the potential effect of turnover as a factor influencing profits without appearing, even in part, to give the impression of saying " look after turnover and profits will look after themselves " is to presume that successful endeavour has *already* been made to reduce to the minimum the cost of securing a particular turnover on a particular farm.

This may appear an academic presumption, but it is the only possible basis if turnover is to be considered on its own merits. It follows from what has been said that in comparing the influence of different rates of turnover under different conditions we must start from the basis that the farms to be compared had either the same rate of profit per cent of capital or the same rate of profit per pound sterling of goods sold.

Apart from reorganization of the capital upon which it is calculated, turnover can be increased either by obtaining better prices for the goods produced or by increasing the physical output itself, and it is interesting to see the relative position which farms with high and low turnovers hold in this respect. In the first place it has to be realized that it will take fully 5¼ per cent increase in physical output to counterbalance a 5 per cent decrease in price at any rate of turnover, even supposing no extra cost is incurred in getting this increased output. On the other hand, the same percentage *decrease in the price* for which the goods are sold means exactly twice as much decrease in total profit on the farm with an 80 per cent turnover as it does on the farm with a 40 per cent turnover, no matter what the basic rate of profit is.

The relative effect which the same percentage *increase in cost* will have on farms with different rates of turnover will, on the other hand, depend on whether the basic rate of profit is the same per cent of capital or per pound sterling of goods sold. In the latter case the same percentage increase in cost will, as before, reduce the total profit of the farm with an 80 per cent turnover twice as much as it will on the farm with a turnover of 40 per cent. If the basic rate of profit be the same *per cent of capital* the relation between rate of turnover and the same percentage change in cost is more complicated and is that for every 5 per cent increase in cost the difference in profit will be 1s. per £100 of capital for every one point difference in rate of turnover. Thus, whatever the basic rate of profit on the capital is taken to be for the two farms, a 5 per cent increase in cost will reduce the total profit of the 80 per cent turnover farm by £2 more per £100 of capital than it will that of the 40 per cent turnover farm.

We see, therefore, that the same percentage decreases in prices, or increases in cost, hit the farms with higher rates of turnover comparatively harder than they do those with lower turnovers. In other words, farms with higher turnovers are relatively more sensitive to price changes, and it might be said that such farms are in a better position to benefit by better times but are, on the other hand, more liable to feel the effect of hard times. While such a statement might be held to endorse the proposition that high farming is no remedy for low prices, it has to be remembered that £5 less 20 per cent is still comfortably above £3 less 10 per cent.

Probably the first effect of " hard times " is the spur given to an overhauling of efficiency in production or, in other words, to reductions in the cost of obtaining the same physical output. Such efficiency should not, and of course does not, always await the spur of hard times but in any case the point will be reached where costs can be reduced only at the expense of reduced output.

In his struggle to maintain his income in the face of falling prices the question which the individual farmer will most frequently ask himself is whether he cannot

increase his physical output of those things which show some margin of profit however small. That is to say, an attempt will be made to make up a reduced profit per bushel or per gallon, by producing more bushels or more gallons. The total expenditure incurred will normally be increased and it may be expected that in order to do no more than maintain his total profit from the farm he will have to push his output to a level which, even at the lower selling price per unit, will in total represent a greater turnover than before.

The following tables make it possible to see what relative effect a 5 per cent increase in turnover would have under different conditions, taking initial turnovers of 60, 80 and 100 per cent respectively.

Presuming the Same Initial Rate of Profit per Unit Sold—1s. in the £1 in each case.

| | | | |
|---|---|---|---|
| Initial turnover .. .. .. .. | 60 | 80 | 100 |
| Initial profit .. .. .. .. .. | £3 | £4 | £5 |
| With increase of 5% in turnover, profit would be :— | £ s. d. | £ s. d. | £ s. d. |
| With no increase in cost .. .. .. | 6 0 0 | 8 0 0 | 10 0 0 |
| With 5% increase in cost .. .. .. | 3 3 0 | 4 4 0 | 5 5 0 |
| With 10% increase in cost .. .. .. | 6 0 | 8 0 | 10 0 |

Presuming the Same Initial Rate of Profit on Capital—5 per cent in each case.

| | | | |
|---|---|---|---|
| Initial turnover .. .. .. .. | 60 | 80 | 100 |
| Initial profit .. .. .. .. .. | £5 | £5 | £5 |
| With increase of 5% in turnover, profit would be :— | £ s. d. | £ s. d. | £ s. d. |
| With no increase in cost .. .. .. | 8 0 0 | 9 0 0 | 10 0 0 |
| With 5% increase in cost .. .. .. | 5 5 0 | 5 5 0 | 5 5 0 |
| With 10% increase in cost .. .. .. | 2 10 0 | 1 10 0 | 10 0 |

In each case the same proportions hold, whatever the basic rates of profits are presumed to be, and it will be seen that an increased turnover of 5 per cent accompanied by an increase in cost fails to maintain the *relative* position of the higher turnover farms so far as rate of profit on capital is concerned.

In the cases where we suppose each rate of turnover to be showing the same initial rate of profit per cent on capital the increases in turnover necessary to show the same return on capital as would be shown by a 5 per cent increase on a turnover of 60 are as follows :—

| | | |
|---|---|---|
| Initial turnover .. .. .. .. .. .. | 80 | 100 |
| No increase in cost .. .. .. .. .. .. | $3\frac{3}{4}$ | 3 |
| 5% increase in cost .. .. .. .. .. .. | 5 | 5 |
| 10% increase in cost .. .. .. .. .. | $6\frac{1}{4}$ | 7 |

That is to say, while an increase of 3 per cent on a turnover of 100 will show the same result as a 5 per cent increase on a turnover of 60 if there is no increase in cost, it will take an increase of 7 per cent to do so if there is a 10 per cent increase in cost.

An actual increase in the quantity of output is, however, not the only way in which rate of turnover may be increased. Mention has been made of the reorganization of the capital. We can suppose a case in which 20 cows would produce 10,000 gallons of milk in the year and that the capital invested in milk production and upon which the

profit would be based would be equivalent to £45 per cow. If the milk were sold for an average of 1s. per gallon the turnover would be 55½ per cent, the output being £500 on a capital of £900.

Now let us suppose that the same total gallonage were obtained from 15 better cows giving an average yield of 666 as against 500 gallons. The cows themselves would be worth more on the average than before and we could say that the capital required might now be equivalent to £50 per cow or £750 in total. The turnover would now be 66⅔ per cent as against 55½ per cent, and even if there were no saving in actual cost per gallon this would represent an increase of one-fifth in the profit per £100 of capital. In each case, however, 10,000 gallons of milk would be produced and unless there were actually a saving in cost per gallon—a saving upon which incidentally the rate of turnover would have no direct influence—the total profit to the farmer would remain just exactly the same.

This brings forward one further point concerning the relationship between turnover and profit. We have just taken a reasonable example in which turnovers of approximately 56 and 67 per cent might show the same total profit *to the farmer* and we may take it as an example of how little we may expect profits *per farm* to correspond with rates of turnover. At the same time, however, we can see in this example the possible effect which turnover may have on the rate of profit on capital; and if we are, in practice, to find that profit is closely connected with rate of turnover, it is to profit *per* £100 *of capital* rather than to profit *per farm* that we shall have to look.

So much for the basis upon which rate of turnover might be regarded as one of the chief factors influencing farm profits. The main points are :—

1. That the advantage of high rates of turnover lies in the fact that for the same total return they permit of lower rates of profit per £ of goods sold and consequently

2. That lower rates of turnover are unlikely to show the same rates of profit on capital unless the goods produced can command prices which compensate for any necessarily low rate of turnover in their production.

3. That it so happens that many of those agricultural products for which it is difficult to obtain a high rate of turnover have recently commanded prices which do not compensate for the slowness in turnover and in consequence a general correlation between turnover and profits shown by a group which covers different types of farms may be as much a reflection of the type of goods produced as of the skill or business activity of the producers.

4. That in spite of the advantages lying in having a high rate of turnover, the same percentage decrease in price or increase in cost at different rates of turnover would mean not only a greater *total* reduction in profit at higher rates of turnover but, under some conditions, a greater *proportionate* reduction.

5. And finally that turnover is a measure of the business done in relation to one only of the " agents of production ", namely, capital; and it must be remembered that the cost of securing a high turnover can be quite out of proportion to the undoubted advantages of high rate of turnover in itself. Conversely the advantages of low cost per unit can largely be negatived in so far as total profit from the farm is concerned if the rate of turnover is unnecessarily low, and it should be obvious that the best chances of a profit are obtained when low cost per unit and high rate of turnover can be balanced together. To strive for one without reference to the other may be to strain at the gnat and swallow the camel.

# THE MICROSCOPIC EXAMINATION OF CATTLE FOODS.*
# SOME POLYGONACEOUS SEEDS

By S. T. Parkinson, B.Sc.

Among the most frequently occurring impurities in cakes and meals are fragments of the fruits, popularly known as *seeds*, of black bindweed, dock, sorrel and knot-grass. Buckwheat is also found and may be a constituent part of the food or an accidental impurity. All these seed-like indehiscent fruits are dark in colour, typically spindle-shaped, triangular in section, and more or less enclosed in a persistent perianth. Embedded in the fruit-coat, and more or less attached to it, is a single seed with a well developed starchy endosperm (Pl. III., Fig. 6). When unbroken, it is an easy task to recognize these fruits with the naked eye, but, when crushed, microscopic examination is necessary. A cursory glance at the hard fragments of the fruit-coat often suffices. Since, however, several characteristic layers occur in the same fruit, it is necessary to consider their appearance in detail; for, unless they are recognized, the analyst may be misled into thinking that *some unknown seed* is present, the name and properties of which he cannot determine.

## COMMON BUCKWHEAT. *Fagopyrum esculentum* Mœnch.†

This fruit is about $\frac{3}{16}$ inch long, and usually triangular in section, with three slightly convex sides narrowing to each end and three sharply marked ridges marking the angles where the sides meet. The margin of these ridges is entire. (Distinction from *F. tartaricum.*) It varies in colour from silvery-grey to dark brownish-black and may be spotted or mottled. Bright when gathered, it becomes dull and darker on drying. The fruit-coat or pericarp is very tough and entirely filled by the single seed. Although inclined to adhere to the pericarp, the seed, after soaking in water, can easily be removed. It consists of a large starchy endosperm in which an embryo with broad folded cotyledons is embedded; so that in a transverse section across the fruit the latter appears S-shaped. (Contrast this with the other seeds such as sorrel, figured in Pl. III., Fig. 6, which are described in this article.) In America the fruit is often husked and the seed milled for flour. This flour is more expensive than that of cereals and is used for making buckwheat cakes and for other special purposes. The bran residues from the milling are used for cattle food. The pericarp or husk is useless for food but is used for packing bulbs and other purposes. In this country buckwheat is only grown occasionally, either as a catch crop or food for fowls and game-birds. Although the plant is often described as a grain crop, it is quite different in root, leaves and other characters from cereals. Yet, as Winton suggested,‡ there are analogies between its fruit and the caryopsis of a cereal. In both we find a dry, somewhat thin pericarp, a single seed with a much reduced seed-coat and an endosperm composed mainly of starch grains.

* This article is a continuation of a series, published in former numbers of this *Journal*, dealing with the examination of seeds and fragments present in cattle foods.

† *F. sagittatum* Gilib. = *Polygonum Fagopyrum* L.

‡ Winton, A. L., "The Microscopy of Vegetable Foods," p. 132. Chapman & Hall, 1916.


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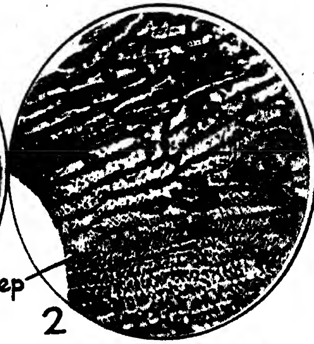

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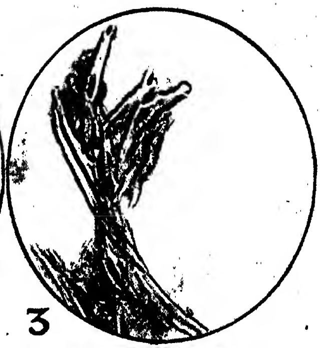
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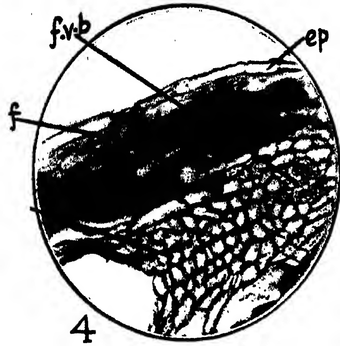

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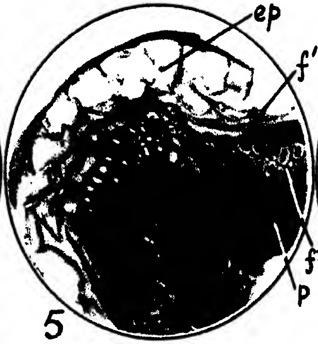

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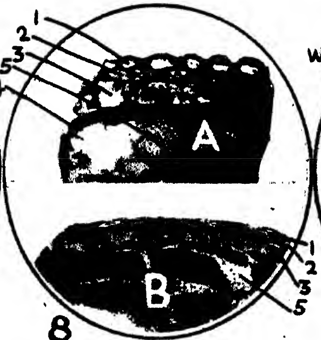

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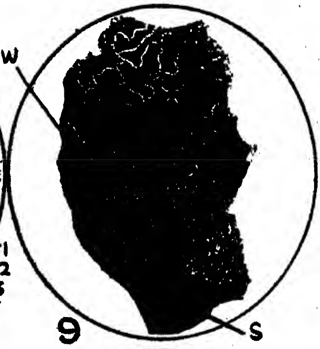

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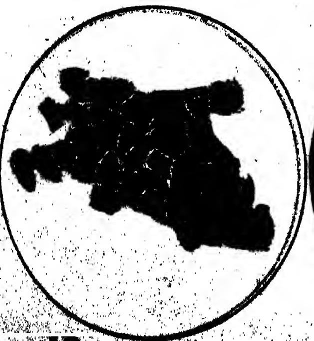
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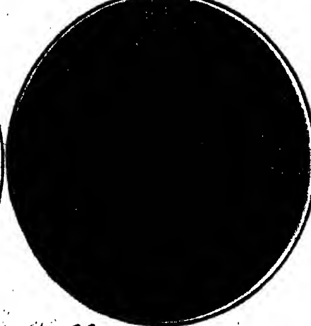
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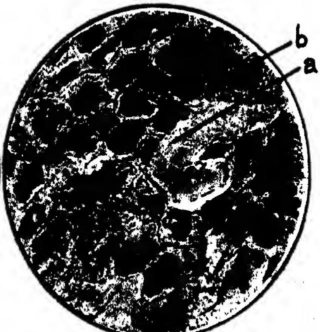

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THE PERIANTH.*

A small five-lobed pinkish perianth is found at the base of the fruit. It is very much smaller than that of the other seeds to be described. Consequently, in a foodstuff, fragments are *comparatively few* and, except from near the base of the fruit, delicate in structure. Pl. I., Fig. 1 indicates the appearance of a typical fragment. The darker lines indicate the position of the veins, which consist of spiral vessels and elongated tracheids and other prosenchyma. The somewhat misleading appearance of parallel veining is distinctive. (Contrast with the coarse reticulation of the dock, Pl. III., Fig. 4.) In the lighter area we find isodiametric, circular, or polygonal cells, the upper walls of which are much thickened, so that in surface view under the H.P. they look like small whitish buttons with a dark centre. Apparently they compose the upper surface of the perianth segment. The mesophyll consists, for the most part, of elongated cells with brown contents. These mask the epidermal cells and the dark colour of the veins is due to the fact that these cells overlay them. Fragments from the converging base of the perianth are similar in most polygonaceous seeds and give the appearance shown in Pl. II., Fig. 9.

A. PERICARP.

On crushing, the fruit-coat breaks up into fragments which are always ragged and tough, with no special projections from the surface ; and not sharply angled as we find them in *Ricinus* or even black bindweed. These shade off from very dark chestnut brown to bright yellow. The bright yellow fibrous portions are often overlaid by a series, or groups, of elongated cells with deep brown contents giving the characteristic appearance seen in Pl. III., Fig. 12, except that in the case of common buckwheat the fibres all run parallel and *do not cross one another*.

1. EPICARP. A transverse section across the fruit (Pl. I., Fig. 4) shows that the epicarp consists of a single layer of tablet-like rectangular cells, elongated (except at the ridges) at right angles to the axis of the fruit. A surface view (Pl. I., Fig. 2 *ep.*) shows two sets of fine striations of the cell wall crossing one another. The cell walls are only moderately thick, so that this layer is apt to be lost or damaged and not easily found when present. Nevertheless, it has diagnostic importance, being quite different from the corresponding layer of *F. tartaricum* (Pl. I., Fig. 5 *ep.*).

2. MESOCARP. The upper part of the mesocarp† consists of layers of short, irregularly-shaped prosenchyma or FIBRE CELLS. These often possess wide cavities filled with dark brown contents. In the photograph, Pl. I., Fig. 4*f*, many of them appear almost black, the walls as well as the contents being discoloured. On a slide they appear yellow and make up the greater part of the thickness of the dried husk. The section shows that, in the different layers, these fibres *run in the same direction* as the epicarp cells, that is to say, almost transversely to the axis of the fruit. In *F. tartaricum*, on the other hand, we find *two* sets of fibres crossing one another (Pl. I., Fig. 5$f^1$

* Throughout this article, dense and coloured tissues are described as they appear after treatment with potash (2½% aqueous KOH solution).

† Winton's *hypoderm.*

and $f^2$, Fig. 6, and Pl. III., Fig. 12). Pl. I., Fig. 3 shows isolated fibres with their characteristic jagged edge. Large yellowish sheets of these fibres are common amongst the fragments. The fibres are less numerous at the angles of the fruit than under the flat sides. Beneath the fibres we find layers of oval and oblong cells. In the angles of the fruit these cells replace the fibres; here they are numerous and show distinctly thickened walls (Pl. I., Fig. 4*p*). Under the flattened sides of the fruit there are one or two layers only of these oval and oblong cells. Most of them contain a dark red-brown colouring matter and their walls often appear brown, possibly due to staining by decomposition products. Winton calls them BROWN CELLS and speaks of them as " impregnated with a brown substance ". Embedded in this portion of the mesophyll are the fibro-vascular bundles (Pl. I., Fig. 4 *f.v.b.*).

3. ENDOCARP. This layer is dried up and largely disorganized in fragments. In surface view Greenish and Collin* figure it as composed of very large pointed cells with thick walls and a wide cavity. Winton figures similar but more rectangular cells. I have not found them in contact with other cells in fragments, though I have seen such a tissue as Winton describes making a fragment by itself. The surface views described and figured in the present paper are those of actual fragments, not such as are obtained by dissection or in surface sections. Therefore, unless these surface views are absolutely diagnostic by themselves, they can only be identified as belonging to the seeds described if they are found as part of a fragment in which other recognized layers occur.

## B. THE SPERMODERM.

In milled buckthorn the fragments of the seed-coat are of great diagnostic importance. They appear as a thin almost transparent membrane with a greenish or light coffee tinge. In transverse section (Pl. I., Fig. 8 A) as well as in surface view (Pl. I., Fig. 9) we find three definite cell series.

1. WAVY CELLS (Pl. I., Fig. 9*w*). Large square or oblong cells with bright undulating, white or yellow walls and no intercellular spaces.

2. STAR CELLS (Pl. I., Fig. 9*s*), resembling those of the spongy parenchyma found in the chaff of oat, but smaller.† The outline of these cells is very irregular, causing the appearance of large circular intercellular spaces. These cells need careful focussing. With a high magnification they are seen to contain remains of a green or brown coloured material, and it is this that gives the characteristic colour to the fragment. Two layers of these cells are usually present.

3. A very transparent layer of elongated rectangular cells with no intercellular spaces. These are not easily seen in surface view. The combination of (1) and (2) in the same fragment is characteristic and diagnostic.

* Greenish and Collin, " Anatomical Atlas of Vegetable Powders," p. 39. J. & A. Churchill, 1904.

† Parkinson and Fielding, " Microscopic Examination of Cattle Foods," Pl. VII, Fig. 4. Headley Brothers, Ashford, 1930.

I am unable to reconcile the character of the layers of the seed-coat with the descriptions given by other authorities. For example, Moeller's* figure of a transverse section of the seed agrees with my photograph of Tartarian buckwheat (Pl. I., Fig. 8 B), where (1) is described as representing the epidermal layer of the testa composed of wavy cells, (2) as the spongy parenchyma composed of the star-shaped cells with circular intercellular spaces and (3) as the aleurone layer of the endosperm ; whereas my section of the seed of the common buckwheat (Pl. I., Fig. 8 A) shows three similar layers but (4), the dark layer beneath them, is composed of cells with thicker walls than (3), and with very dense contents and appears to correspond much more closely with a typical aleurone layer than (3) does.

C. ENDOSPERM.

1. ALEURONE. A single layer of aleurone cells is present. It resembles those of cereals but the component cells are smaller and more variable in shape. A surface view of this layer is shown in Pl. I., Fig. 10.
2. STARCH-CONTAINING CELLS (Pl. I., Fig. 8 (5)). Except at the margin of the endosperm these are very large. The majority are polygonal and crowded with starch grains. On mixing with warm water many of these cells, or their contents, separate without breaking up so that we have large polygonal blocks or " packets " of starch grains, like those depicted in Pl. II., Fig. 7. The starch grains themselves are polygonal, very small and with a well marked central hilum. As the photograph (Pl. I., Fig. 11) shows, two or three may join to form small constricted rods. They are thus very much like those of rice or oat grains but the aggregates are never rounded. Vogl, on treating the endosperm with alkali, found the starch grains dissolved, leaving a reticular meshwork of ground tissue in which they had been embedded. In the potash treatment used for the preparation of fragments I have not observed this reticulation. Vogl says that in the case of buckwheat the boundary lines forming the walls of the reticulations are plain while in the case of millet they are beaded.

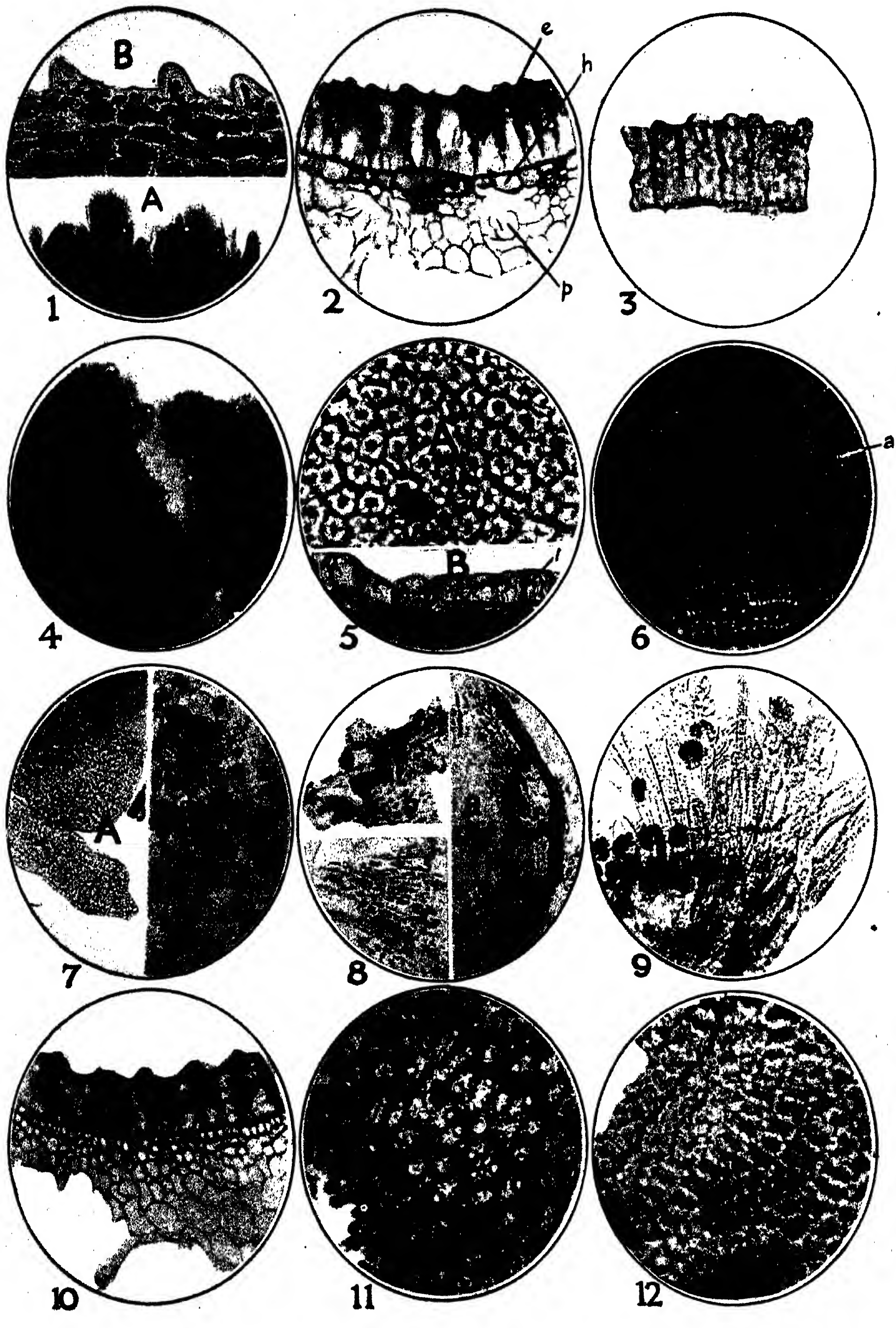
D. EMBRYO.

The embryo of buckwheat is much larger than in the other genera described. The cotyledons are broad and folded and form an S-shaped structure stretching right across the transverse section of the seed. The outside edges of the folds run parallel and close to the spermoderm. As the cotyledons are large, fragments often show veining.

POINTS OF DIAGNOSTIC IMPORTANCE.

1. Simple leaf-like character of perianth.
2. Epicarp cells not prominent ; cross striations present.
3. Fibres running parallel to one another. Form yellow patches often overlaid by tube-like brown cells.
4. Wavy and star-shaped cells associated with green or brown colouring matter form the spermoderm.
5. Large angular aggregates of starch grains. Individual polygonal grains very small.

* Winton, op. cit., p. 134.



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## TARTARIAN BUCKWHEAT. *F. tartaricum* Gaert.

The fruit of this plant is cone-shaped, smaller and narrower than that of common buckwheat and is easily distinguished from it because the three ridges have an ***undulating*** edge. The only specimens I could procure were dull and practically black.* The seed is not so valuable as, but is commonly found in consignments of, common buckwheat.

### PERIANTH.

The seeds I examined had hardly any trace of perianth.

### A. PERICARP.

Fragments similar to those of common buckwheat, but the fibres cross one another instead of running parallel. (Pl. III., Fig. 12.)

1. EPICARP. (Pl. I., Fig. 5 *ep.*) From the transverse section it is seen that the epidermal cells are quite different from those of common buckwheat. They are much larger, square or oblong with thin lateral and thicker external walls. The internal walls are thin and fit into concave depressions in the layer of fibre cells below. In the specimens I examined they were obscured by intensely black pigment and the surface view was difficult to determine. Pl. I., Fig. 7 shows the black pigmented substance and the thick porous and striated walls of the fibres below. The radial walls of these cells are longer at the angles than on the sides of the fruit, which is not the case with the common buckwheat. As in common buckwheat these cells are generally in a disorganized condition when found in fragments.
2. MESOCARP. The section clearly shows the two sets of *fibre-cells* running at right angles to one another. In the outer layer (Pl. I., Fig. 5 $f^1$) the cells are more irregular in shape and are elongated in the same direction as those of the common buckwheat. The inner fibres run in the direction of the axis of the fruit and Pl. III., Fig. 12 and Pl. I., Fig. 6 show how the crossed sets of fibres appear when looked at from the surface.

### B. SPERMODERM. (Pl. I., Fig. 8B.)

This has been discussed on p. 27.

The other tissues have practically the same structure as in common buckwheat.

#### POINTS OF DIAGNOSTIC IMPORTANCE.

As in common buckwheat with the exception of :—

1. The large square or oblong EPICARP CELLS, with convex inner wall.
2. Two sets of FIBRE CELLS crossing one another.

## BLACK BINDWEED. *Polygonum Convolvulus* L.

This annual plant and the perennial field bindweed (*Convolvulus arvensis* L.) are the most troublesome of twining weeds. The former is easily distinguished by (1) its

*** These were obtained through the courtesy of Messrs. Vilmorin, Andrieux & Cie, Quai de Mégisserie, Paris, who very kindly picked them out from imported consignments of another variety.**

raceme of small pinkish flowers, (2) the ochrea, (3) absence of spreading underground stem and (4) its triangular fruit. It can be exterminated by cultivation but is continually introduced in seed and growing up round the stems of cereals cannot be dealt with till after harvest. Consequently the seeds of this plant form one of the most common impurities of cattle foods. It cannot be said to be deleterious but the analyst should be able to recognize it when present. Its nut-like triangular fruit, except that it is *coal-black* and *smaller*, resembles that of buckwheat.

PERIANTH.

The perianth is large and, unlike that of buckwheat, more or less encloses the whole fruit, giving it a grey appearance after drying. It is therefore likely to be quite a prominent feature in a cake where bindweed is present. After harvesting it becomes dry and easily breaks up into a powder in which it is somewhat difficult to recognize its constituents. After treatment the fragments appear yellow or reddish-brown. Pl. II., Fig. 1 B is a photograph of a section showing the characteristic *conical projections* of the upper epidermal cells. These cells have thick and *very finely striated* walls. Looked at from above, in fragments, these cells appear, in optical section, as numerous thick or thin-walled circles; near the margin of the perianth segment or where the epidermis has been stripped away as a single layer, they look like a number of very thin-walled colourless bladders. A different, but typical, surface view is seen in Pl. I., Fig. 12, where we see the striated epidermal projections (*a*) and mesophyll cells (*b*) containing a dark pigment. The mesophyll is also seen as rectangular cells filled with a chestnut brown colouring matter in Pl. II., Fig. 1 B. Some of the fragments become very opaque and stained and Pl. II., Fig. 1 A shows the margin of such a one, which was almost black, even after treatment with potash. The epidermal projections were the only features that could be distinguished and they were stained brown.

A. PERICARP.

Whilst the thicker fragments are coal-black and generally angular, the thinner ones are dark brown or very bright yellow, covered all over with small blunt projections.

1. EPICARP. This is a palisade layer consisting of elongated column-like cells, much thickened on the exterior and on the wavy radial walls. These radial walls thin out at the base so that the cells present the very characteristic appearance shown in the transverse section, Pl. II., Fig. 2*e*. If such a section is double-stained with safranin and haematoxylin, the external and upper radial part of the thickening remains brilliantly yellow while the rest shows the ordinary lignin reaction. The exterior wall of many of the cells is domed, as is clearly seen in the section. In well crushed material, isolated cells or groups of cells such as those seen in Pl. II., Fig. 3 separate out. They appear a brilliant glistening yellow. Pl. II., Fig. 4 shows very plainly the character of this layer as seen from the surface. The irregular, much thickened walls of the cells, with their star-shaped outlines, are clearly seen where they project into the cleft of the fragment. The dome-like projections are also prominent, arranged in more or less definite lines. In optical section, at a lower level, the outline of the cells alters; and we obtain the appearance very well shown in Pl. II., Fig. 5 A.

2. MESOCARP. A very distinct layer immediately beneath the epicarp is well shown in Pl. II., Fig. *2h.* This may be called the ***hypoderm*** and its cells have decidedly thicker walls than those of the rest of the mesocarp which consists of a varying number of layers in which the fibro-vascular bundles occur. In surface section these cells with their contents are stained a dark brown. There is a complete absence of the plates of yellow fibres with their brown contents which were such a prominent feature in the mesocarp of buckwheat.

3. ENDOCARP. Although plainly marked in a transverse section of a young and fresh fruit it is generally too crushed to be recognized in dry fragments.

B. SPERMODERM.

The seed drops out when one attempts to cut a section across the fruit and after soaking in water the spermoderm strips off as an almost transparent membrane. Fragments are easily found in the water-treated material of a cake. A section across this part of the seed is photographed in Pl. II., Fig. 5 B. As in buckwheat this membrane is of great diagnostic importance. A surface view is shown in Pl. II., Fig. 6. We can distinguish three layers of cells.

1. An outer layer of elongated oblong cells, with only slightly undulating walls. These are the large cells which run from left to right in the photograph. In the transverse section the side walls of these cells are seen to have collapsed and to be wavy.

2. A number of very small irregular or rod-like cells with thin walls and elongated in a direction *at right angles* to those of the outer layer. These *cross-cells* can just be distinguished as faint lines in the photograph. They contain a small quantity of a greenish or brownish substance which is sufficient to give the characteristic greenish or greenish-brown tint so often found and so very characteristic of the fragment. Fragments from the pointed end of the seed may show these rod-like cells with thicker highly refractive walls, closely packed and filled with bright green or brown matter, and thus producing a striking effect.

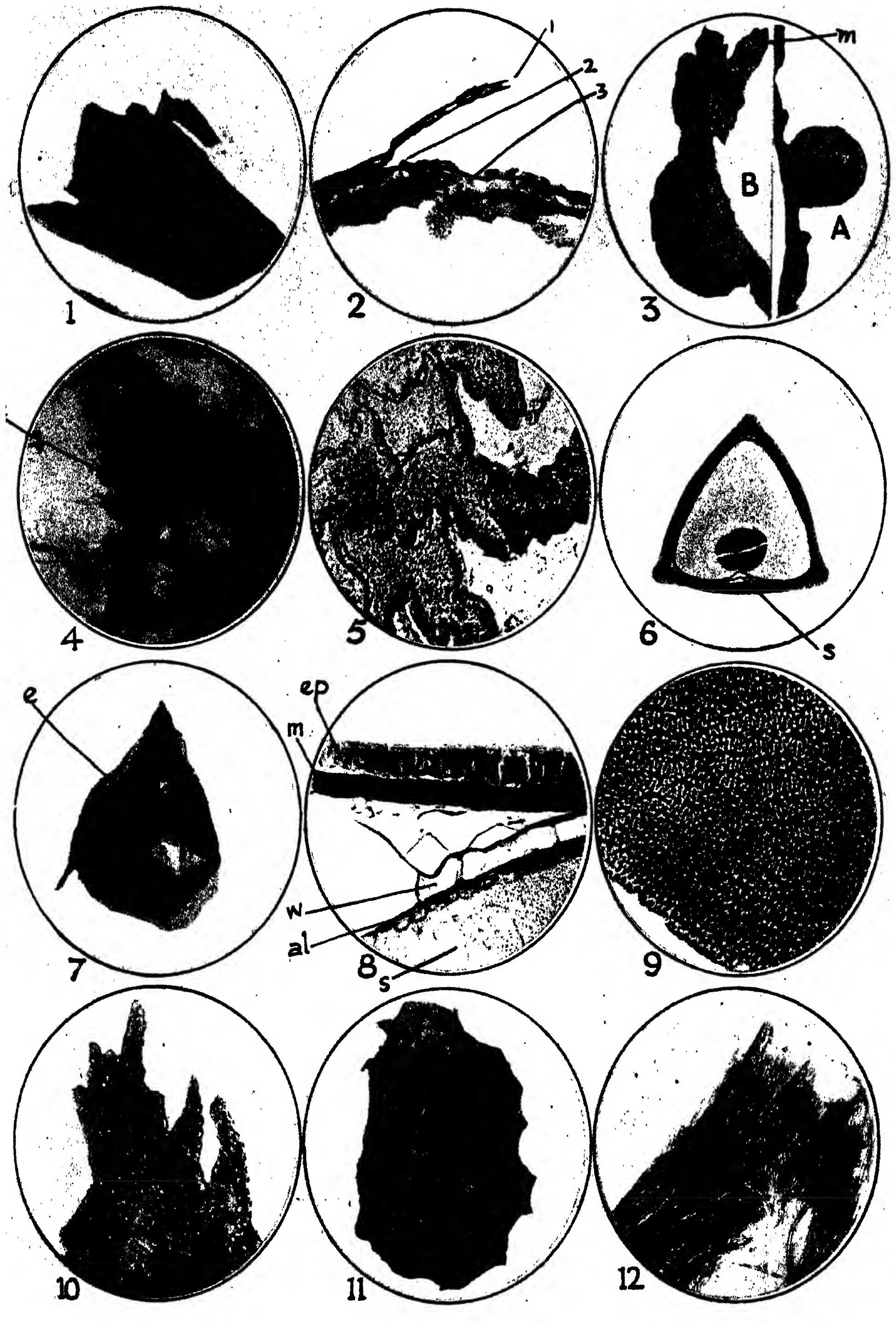
3. Extremely thin-walled elongated cells running parallel to (1). These are generally difficult to find and are usually better seen where plates of aleurone cells occur.

C. ENDOSPERM.

The aleurone layer (Pl. II., Fig. 6 *al.*), starch-containing cells and starch grains are similar to those of buckwheat.

D. EMBRYO.

The cotyledons are not folded and are much smaller than those of buckwheat.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### Points of Diagnostic Importance.

1. Bladder-like projections on perianth.
2. Very dark angular fragments of husk with shining yellow appearance at the edges.
3. Bright yellow epicarp with its dome-like projections.
4. Isolated epicarp cells.
5. The star-like cells (spongy parenchyma) of buckwheat replaced by irregular or rod-like *cross-cells.*

## KNOT-GRASS. *Polygonum aviculare* L.

Although this plant is a common weed, the fruit is not plentiful in foodstuffs. It is rough, dull brown, almost black, 2-3 mm. in length, roughly triangular in section, blunt at the base where it carries remnants of perianth and stalk, and snout-like at the other end. It is somewhat pear- or bellows-shape. A transverse section shows the sides concave, as though they had been pinched in, not convex as in the case of sorrel which is figured in Pl. III., Fig. 6.

### PERIANTH.

The character of fragments is shown in Pl. II., Fig. 8. The *well developed fibrous meshwork* of the veins distinguishes them from those of buckwheat. Pl. II., Fig. 9 shows the character of a fragment from the basal end. The dark blotches represent rather thick-walled cells with brown contents. This fragment is typical of polygonaceous fruits generally. In the spaces of the network three types of tissue are easily distinguished: (1) rectangular cells with moderately thick walls and brown contents forming a tissue similar to the mesophyll of bindweed (Pl. II., Fig. 8*c*), (2) similar cells with much thicker walls, so that the dull dark plasmolyzed contents appear much separated (Pl. II., Fig. 8*b*) and (3) very thick-walled oblong stratified cells with wavy walls and brown contents. Many of the fragments thin out at the edge and so become almost transparent.

### A. PERICARP.

Fragments are irregular in shape, often *curved*, and dark reddish-brown to yellow in colour. The surface shows a reticulated appearance due to thick-walled wavy cells, and on re-focussing rows of delicate button-like projections. Very thick fragments appear almost black at the centre but usually shade off to the typical brown and yellow at the edges.

1. Epicarp. This layer resembles that of black bindweed but the cells are shorter and the radial walls are even more irregular, so that the very pronounced projections of neighbouring cells interlock closely. Transverse sections (Pl. II., Fig. 10) show that the cells vary little in depth right round the fruit. They are a little longer at the corners of the ridges whereas those of black bindweed are twice as long in that region as on the sides. Isolated *groups of cells*, in the position of those of bindweed (Pl. II., Fig. 3) are not very common. When they occur the cells appear short and stumpy and nearly as broad as long. More often we see the separated yellow cells as

very thick-walled and star-shaped, and, as they appear when looking down on the surface of a fragment (Pl. II., Fig. 11). The external surface of the cells projects, so that rows of cells with dome- or button-like projections occur. On focussing downwards the cell cavity of the projection appears as a dark centre to the button. On focussing still further the star-shaped outline of the cell becomes evident. (Pl. II., Fig. 11.) Focussing downward still further, we have the appearance well seen in Pl. II., Fig. 12, where the dark areas indicate cell cavities and the lighter areas the cell walls. This should be contrasted with the appearance of the epicarp of bindweed shown in Pl. II., Figs. 4 and 5. Fragments show a bright yellow colour with a meshwork of orange streaks which indicates the direction followed by the dome-like projections. These orange-brown lines are indicated by the black shadows in Fig. 11.

2. MESOCARP. This tissue is of little diagnostic importance. From the transverse section (Pl. II., Fig. 10) it will be noticed that the size of the mesophyll cells of the different layers increases while the thickness of the walls decreases towards the interior. As the fruit ripens the cells become disorganized and the walls discoloured, and the fibres accompanying the vascular bundles give a fibrous character to the yellow fragments (Pl. III., Fig. 1). These fragments, when associated with others showing the epicarp cells, are of diagnostic value.

B. SPERMODERM.

As in other cases, fragments appear almost transparent and spotted with green and sometimes stained a bright light brown colour. They are not numerous as the membrane is not so readily stripped from the fruit-coat and endosperm as in the case of the other seeds described. The outer layer (Pl. III., Fig. 2 (1)) consists mainly of thin-walled, elongated cells with *wavy or undulating* walls. Below this, in the section, we find the remains of a thin crushed layer (Pl. III., Fig. 2 (2)). In the fragments examined no trace could be found of star- or rod-shaped cells, such as exist in buckwheat or bindweed ; but patches of bright green (sometimes brown) plasma-like substance were visible in surface view. For the most part they follow the margins of the undulating walls of the epidermis and probably represent the crushed layer referred to. Beneath these there is a well-marked layer (Pl. III., Fig. 2 (3)) which is probably the aleurone layer of the endosperm.

C. ENDOSPERM.

The cells of the aleurone layer are slightly larger than those of buckwheat. Starch-containing cells and starch grains are of the type previously described.

D. EMBRYO.

The radicle is situated in one of the angles of the seed. The cotyledons are narrow and convex in section.

POINTS OF DIAGNOSTIC IMPORTANCE.

1. Well-developed fibrous network and characteristic mesophyll of the perianth.
2. Colour and character of the epicarp cells and its association with yellow fibrous fragments of mesocarp.

## DOCK AND SORREL. *Rumex* spp.

The shining chestnut-brown fruits of docks and sorrels are all similar in structure and appearance. They are triangular in section (Pl. III., Fig. 6) and most of them vary from one-sixteenth to one-twelfth of an inch in length. Sheep's sorrel (*R. acetosella* L.) is about half this size. Unless otherwise stated the following description refers to the curled dock (*R. crispus* L.).

### PERIANTH.

As is well known the fruit of the dock is surrounded by six perianth leaves, the three inner of which form a massive three-winged, more or less persistent covering to the fruit. It is, therefore, not uncommon or surprising to find *a good many* fragments of the perianth where dock occurs as an impurity. In such fragments we find a *very strong vascular network* composed of vessels, tracheids and the usual fibro-vascular bundle tissue. This is well shown in Pl. III., Fig. 4. In cases where glands occur they may occasionally show in fragments as seen in Pl. III., Fig. 3. In this figure a hand-section (A) cut from an immature flower may be compared with a much more massive dried fragment (B) obtained from crushed seed. Tissues characteristic of the perianth of dock are :—(1) the epidermal cells (Pl. III., Fig. 4*e*). Under the L.P. of a microscope these appear as small reddish-brown dots. Under the H.P. they are seen to form a distinct tissue without intercellular spaces. The external wall of these cells is very thick and the top of the cell protrudes as a small, somewhat flattened dome. (2) plates of cells with brown contents (Pl. III., Fig. 3*m*) similar to those forming the mesophyll of knot-grass, and (3) gigantic irregular wavy cells with thickened coloured walls (Pl. III., Fig. 5). Transparent cells of the same shape with thinner walls form the inner epidermis of the thinner portions of the perianth segment.

### A. PERICARP.

Bright yellow or reddish, smooth fragments, such as that shown in Pl. III., Fig. 7, which are curved or pointed or both, frequently occur.

1. Epicarp. The cells of this layer are quite characteristic. In surface view the walls appear wavy but a transverse section across the fruit (Pl. III., Fig. 8 *ep*) shows them as rectangular cells with greatly thickened and cuticularized radial and external walls. This layer shows as a *bright shining yellow band*. At the angles these radial walls are considerably longer than on the flatter sides of the fruit-coat. In surface view of fragments, this layer appears yellow and bright and the cell walls show as continuous wavy lines, well seen in Pl. III., Fig. 9. There are no knob-like projections, such as occur in bindweed and knot-grass. The cells are more or less bound together by the massive cuticle and are not found isolated as was the case with bindweed and knot-grass. Plate III., Fig. 10 is a surface view of some cells near the apex showing elongation in the direction of the fruit axis.

2. Mesocarp. This is represented by the dark stripe in the photograph (Pl. III., Fig. 8*m*) and consists of several layers of more or less tabular or cylindrical cells. In transverse section these appear circular near the epicarp and oblong near the inner surface. They are filled with a dense brown material and the walls also stain brown. In fragments viewed from the surface

they form characteristic bright reddish-brown patches (the black parts of Pl. III., Fig. 7) above or below the bright yellow epicarp (*e*), and isolated cells of various shapes (discs, rods, etc.) are also scattered about in the same way.

3. ENDOCARP. A single layer of crushed and disorganized cells radially elongated.

B. SPERMODERM.

Surrounding the endosperm and beneath the pericarp a layer of very large thin-walled cells can easily be seen in Pl. III., Fig. 6*s*. They form the greater part of the " skin " or seed-coat. As with the other seeds described, this separates easily and pieces of it occur in foodstuffs as membranous almost transparent fragments with a slight brown tinge. These fragments consist mainly of the layer just described. In the transverse section, Pl. III., Fig. 8*w*,* the thin-walled cells which compose it appear more or less rectangular. In surface view, Pl. III., Fig. 11, the cells are shown to have the wavy outline characteristic of the spermoderm in the Polygonaceae. They are much larger than the corresponding cells in the other seeds described. As with knot-grass a greenish border appears to follow the outlines of the wavy walls. This colouring matter doubtless belongs to a layer corresponding to the star-cells of buckwheat but in the fragments I have observed the aleurone layer (Pl. III., Fig. 8 *al*) appears directly underneath the wavy cells.

C. ENDOSPERM.

In the transverse section (Pl. III., Fig. 8) and beneath the layer of wavy cells (*w*) we find an indeterminate structure which may represent the mesophyll and inner epidermis of the seed-coat. After this we find a very distinct layer of somewhat thick-walled cells the dense contents of which stain very deeply with haematoxylon. This is almost certainly the *aleurone layer*. (The lower dark line in Fig. 8.) In surface view the aleurone cells appear as in Pl. I., Fig. 10.

D. EMBRYO.

As seen in Pl. III., Fig. 6, the embryo lies close to the *middle* of one side of the seed. The section shows the narrow convex cotyledons.

POINTS OF DIAGNOSTIC IMPORTANCE.

1. The massive veins and large wavy cells of the perianth.
2. The smooth yellow margin to the curved chestnut brown fragments of the pericarp.
3. The epicarp cells with their wavy outlines and no external projections.
4. The very large size of the wavy cells of spermoderm fragments.

My thanks are due to Mr. R. M. Harrison, B.Sc., for help in cutting and staining sections and to Mr. E. C. Bolton, B.Sc. and Mr. F. R. Peters, B.Sc., for co-operation in preparing some of the fragments and photographs.

* In the left hand part of this photograph some of the large wavy cells are seen in surface view. In no part of the seed is this layer more than one cell thick.

# EXPLANATION OF FIGURES.

## Plate I.

Fig. 1. *Fagopyrum esculentum*, perianth × 40.
Fig. 2. ,, surface of pericarp, *ep.* epicarp × 250.
Fig. 3. ,, fibres × 170.
Fig. 4. ,, transverse section across ridge of fruit × 170. *ep.* epicarp, *f.* fibres, *f.v.b.* fibro-vascular bundle, *p.* parenchyma.
Fig. 5. *F. tartaricum*, transverse section across ridge of fruit × 170. *ep.* epicarp, $f^1$ outer layer of fibres, $f^2$ inner fibres, *p.* parenchyma.
Fig. 6. ,, crossed fibres × 170.
Fig. 7. ,, surface of pericarp × 170.
Fig. 8 A. *F. esculentum.* Layers of seed coat × 170.
Fig. 8 B. *F. tartaricum.* Layers of seed coat × 170.
Fig. 9. *F. esculentum.* Wavy cells of seed coat × 170.
Fig. 10. ,, aleurone cells × 170.
Fig. 11. ,, starch grains × 170.
Fig. 12. *Polygonum Convolvulus*, surface of perianth × 170.

## Plate II.

Fig. 1. *Polygonum Convolvulus*, epidermis of perianth × 170.
Fig. 2. ,, transverse section across pericarp × 170. *e.* epicarp, *h.* hypoderm, *p.* parenchyma.
Fig. 3. ,, epicarp cells × 170.
Fig. 4. ,, surface of epicarp × 170.
Fig. 5 A. ,, surface of epicarp, on re-focussing × 170.
Fig. 5 B. ,, transverse section of seed coat × 170.
Fig. 6. ,, surface view of seed coat × 170, *al.* aleurone cells.
Fig. 7 A. ,, starch " packets ", after treatment with potash × 170.
Fig. 7 B. *Fagopyrum tartaricum.* Starch packets examined in water × 40.
Fig. 8. *Polygonum aviculare.* Surface view of fragments of perianth, (a) × 25, (b) × 40, (c) × 25.
Fig. 9. ,, Surface view of fragment from basal end of perianth × 170.
Fig. 10. ,, transverse section across pericarp × 170.
Fig. 11. ,, surface view of epicarp × 170.
Fig. 12. ,, *ditto* on re-focussing × 170.

## Plate III.

Fig. 1. *Polygonum aviculare*, yellow fragment × 170.
Fig. 2. ,, transverse section across seed coat × 170.
Fig. 3. *Rumex crispus*, section and fragment of perianth, (A) × 25, (B) × 40.
Fig. 4. ,, surface view of fragment of perianth × 25.
Fig. 5. ,, wavy cells of perianth × 170.
Fig. 6. *R. Acetosa*, transverse section across seed × 25.
Fig. 7. *R. crispus*, typical fragment of pericarp × 25.
Fig. 8. *R. Acetosa*, section across pericarp and seed × 170. *ep.* epicarp, *m.* mesocarp, *w.* wavy cells, *al.* aleurone layer, *s.* starch containing cells.
Fig. 9. *R. crispus*, surface view of epicarp × 170.
Fig. 10. *R. Acetosa*, surface view of epicarp at base of fruit × 170.
Fig. 11. *R. crispus*, surface view of seed coat × 170.
Fig. 12. *Fagopyrum tartaricum*, surface view of crossed fibres of pericarp × 40.

# INVESTIGATIONS ON MACHINERY USED IN SPRAYING

## PART I. NOZZLES

By Cornelius Davies and G. R. B. Smyth-Homewood,

*Department of Engineering.*

### Introduction.

It is not necessary to stress the case for the efficient application of insecticides and fungicides to fruit trees to keep the various pests which attack them under control so as to enable growers to produce more and better fruit. For many years biologists have studied these pests and have produced remedies, the majority of which take the form of chemicals applied either in the liquid state or in the form of powder. Manufacturers of spraying tackle have done much to introduce improved machinery, but the amount of time they can devote to research is necessarily limited and so they naturally tend to produce what is demanded by growers. It is certain that no engineers have studied the problems of the mechanical application of liquids and powders in the same way that biologists and their associated chemists have studied their problems, and it is now necessary that engineers should keep pace with other scientific advances for the control of pests and devise means of applying chemicals in an efficient way or on a large scale. The fact that there are, even to-day, so many conflicting opinions, not only concerning what is wanted in equipment, but even as to what existing appliances will do, is in itself sufficient to justify an investigation such as we have undertaken. A comprehensive scheme has been prepared and although no special funds have been forthcoming sufficient machinery and apparatus has been begged, borrowed, made or re-conditioned to carry the initial work a satisfactory distance forward. Encouraged by the Research and Advisory Committee and those research officers of this College who have spent many years studying pests and their control, the Agricultural and Horticultural advisers of the area, manufacturers of spraying machinery and others, we have made sufficient progress to realize more than ever the urgent need for fundamental research on this question, and have appreciated the fact that we are in a unique position for the undertaking of the work, being situated in the heart of a fruit growing district and having the great advantage of immediate approach to and advice from, a large number of practical growers and many of the very chemists, entomologists, mycologists and technical advisers who are best acquainted with the many aspects of spraying.

### The Scope of the Work Done.

Knowing that whatever the disadvantages of this method are, most chemicals are in fact applied in a liquid state, it was decided to study liquid spraying machinery first. Further, realizing that many spraying nozzles on the market are capable, with suitable adjustments, of producing anything from a solid jet of liquid to the misty spray sometimes demanded, we started our investigations at the nozzle end of spraying equipment. It might be contended that this is the ultimate and therefore the wrong end at which to start; but when it was seen that very little was known about the effect of

pressures and output on economical and efficient spraying, and when it is known that the making and driving of pumps capable of any reasonable output and pressure is a matter of known engineering formulae once the requirements are stated, it was decided that nozzles should be our first line of study. It must not be inferred that we are of the

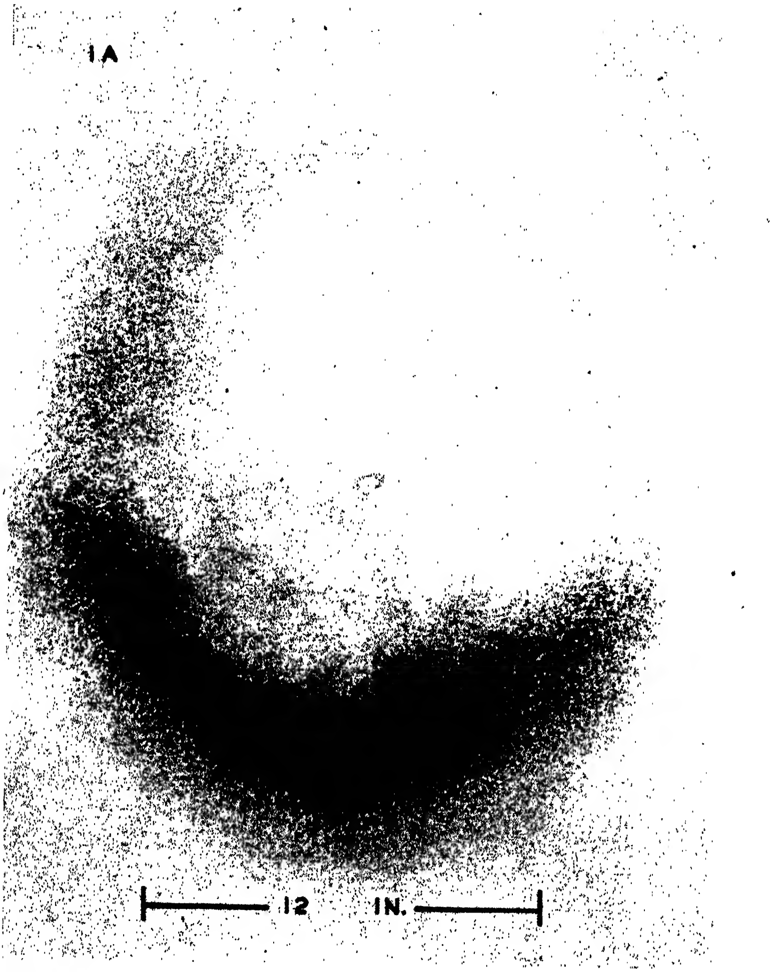


FIG. 1A.—A typical stationary spray pattern made by a nozzle fitted with a No. 2 disc and with a pressure of 200 lb. per sq. in. The heavier deposit on one side, which was common, can be noted.

opinion that making spray pumps is a comparatively simple matter—we are only too well aware of the many difficulties met with which have yet to be overcome—but our contention is that it is not yet known with any measure of accuracy what the requirements are. For example, manufacturers have in some cases been persuaded to make what are called high pressure outfits, and these have apparently given satisfaction in

many cases, and perhaps are a step in the right direction ; but the methods by which they are sometimes tested in the field do not always yield sufficient data to enable impartial observers to make accurate comparisons. We obtained equipment whereby pressures of anything up to 800 lb. per sq. in. could be generated. Some of this was

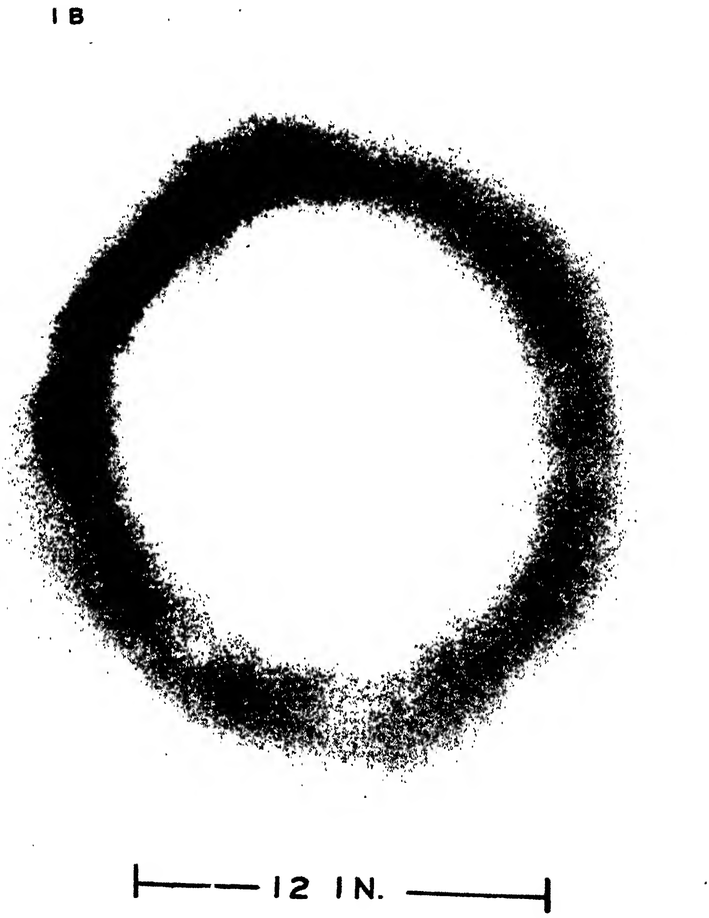


Fig. 1b.—A complete ring spray pattern. A greater concentration on one side is noticeable. This was also made by a nozzle fitted with No. 2 disc and with a pump pressure of 200 lb.

hand worked and some driven by motors, but providing the pressures required were obtained we were naturally indifferent, in this experimental stage, about the economic soundness of the method. The economical production of definite pressures and outputs will be investigated later when it is known with more precision what they should be.

NOZZLES.

The majority of nozzles in common use belong to the *eddy-chamber* class. In these the liquid is made to rotate in a chamber at a high speed by directing it therein through one or more spiral or tangentially arranged channels, before it is forced out of the orifice

1 C

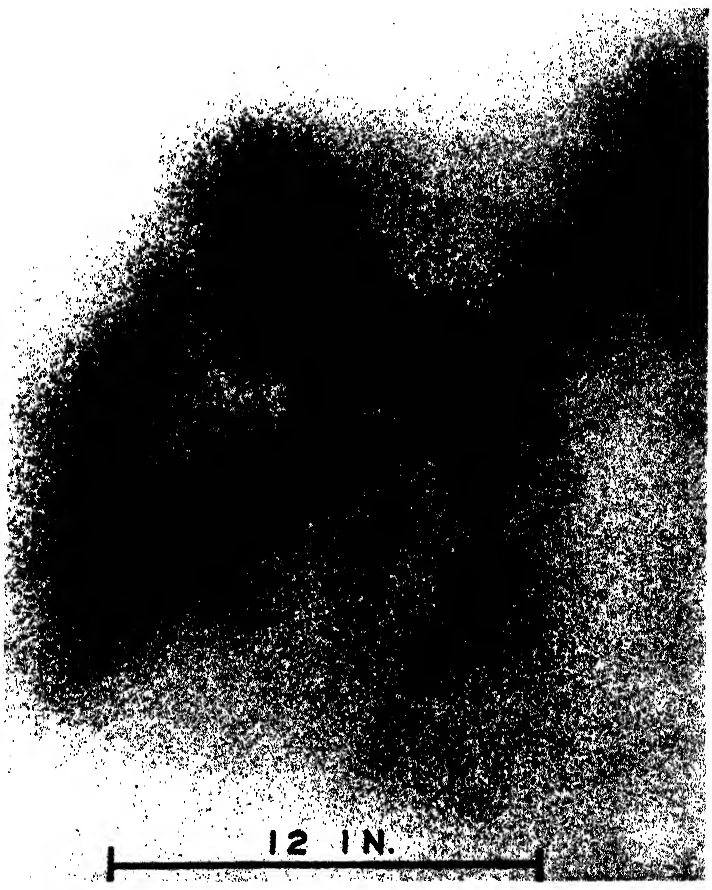


FIG. 1C.—A typical unsymmetrical stationary spray pattern. All the nozzles tested produced patterns similar to this under certain conditions. The pressure used in this case was 200 lb. and the disc was a No. 2.

of the nozzle. The eddy-chamber is also called among other terms, the swirl-chamber, the whirl-chamber, the vortex-chamber. This miniature whirlpool tends to break up the solid stream of liquid into a spray, fog or mist, as it leaves the nozzle, and the fineness of the spray depends on various factors which are presently to be discussed. There are nozzles which work on other principles, such as those which atomize the liquid

by means of specially designed outlets—a rubber garden hose squeezed between the thumb and finger is a crude form of this type—and those which depend upon an obstruction placed in front of the solid jet of liquid issuing from a round hole ; but these we have not studied. Some of the eddy-chamber nozzles are so constructed that it is possible


FIG. 1D.—This shape of stationary pattern produced the best traverse patterns. It will be seen that the atomization is not so fine as A, B and C despite the fact that the smaller No. 1 disc orifice was used ; the reason being that the pressure was only 50 lb. per sq. in.

to vary the depth of the eddy-chamber ; others are fixed in depth ; most make provision for having different sized *nozzle orifices*, that is the last hole through which the liquid issues before being directed at the object to be sprayed ; others again are provided with mechanism whereby the sizes of the tangential or spiral passages leading into the eddy-chamber can be altered. The object of these various devices is to enable

the grower to obtain different forms of *spray cones.* (The shape of the broken up stream of liquid outside the nozzle is generally cone-shaped with the apex of the cone in contact with the nozzle.) Yet another factor influencing the form of spray is the pump pressure.

## Stationary Nozzle Tests.

So many different opinions concerning the effects of these adjustments were found to exist that it was resolved to obtain data which were not a matter of conjecture. Various methods were tried and abandoned to obtain permanent records of the form of spray produced with different nozzle settings, pressures and distances before the final apparatus was designed with the aid of which it is possible to get permanent "spray patterns" with exposures of anything from one-hundredth of a second upwards. Fig. 1, A, B, C and D are photographic reproductions of some of the patterns produced with this apparatus. These patterns give a record of the shape of a section through the spray cone, the symmetry of the cone, the degree of atomization, the density of the deposited liquid, the area of effective "cover" and other information which is of immediate value. In producing these patterns the nozzles were fixed securely to a stand, and to distinguish them from other patterns, which are dealt with later, they are called *stationary patterns.* It must be borne in mind that it is not possible to obtain such patterns in the field, and at first sight they may appear to have but an academic interest. This is not the case, however, because it is difficult to make much progress in such an investigation as this unless the evidence provided by such stationary patterns is available. When the combinations of the four factors: adjustable orifices, depths of eddy-chamber, distance from the sprayed object and various pressures are calculated it will be realized that it is possible to obtain an enormous number of stationary patterns. Preliminary experiments were made and from the results furnished by them it was possible to decide what variations to use for final test purposes. Even so something approaching six hundred patterns have been obtained with less than half-a-dozen commercial nozzles. The problem of analysing and judging these patterns was not easy to solve, not only because of the tedious work involved, but also because it was difficult to decide on standards of excellence—biologists themselves do not agree as to what constitutes the ideal, there being a tendency for mycologists to favour the finer mist-like cones, and entomologists seem to require something with more driving power behind it, even to the extent of causing spray liquid to drip from the trees. It appears, however, that all would be satisfied if every part of sprayed objects were evenly covered with a finely divided stippled deposit, and such patterns as were covered in this way were deemed to be better than those showing coarse droplets irregularly spread. Fig. 2 gives photographs of patterns actually made by a nozzle, which show fine, medium and coarse portions from stationary patterns. All the nozzles experimented with produce ring-like stationary patterns, as usually set for close spraying, showing that the cone of spray is hollow. But these rings are not produced under all conditions, and it remains to be demonstrated that they are less effective and expeditious in spraying a tree completely than disc-like patterns, such as Fig. 3. Each pattern was judged under the following headings:

*Shape.*

| | | |
|---|---|---|
| Complete ring. | Complete disc. | Ring with some deposit in centre. |
| Half ring. | Broken disc. | Half ring with some spray in centre. |
| Broken ring. | | Broken ring with some spray in centre. |
| Half broken ring. | | |

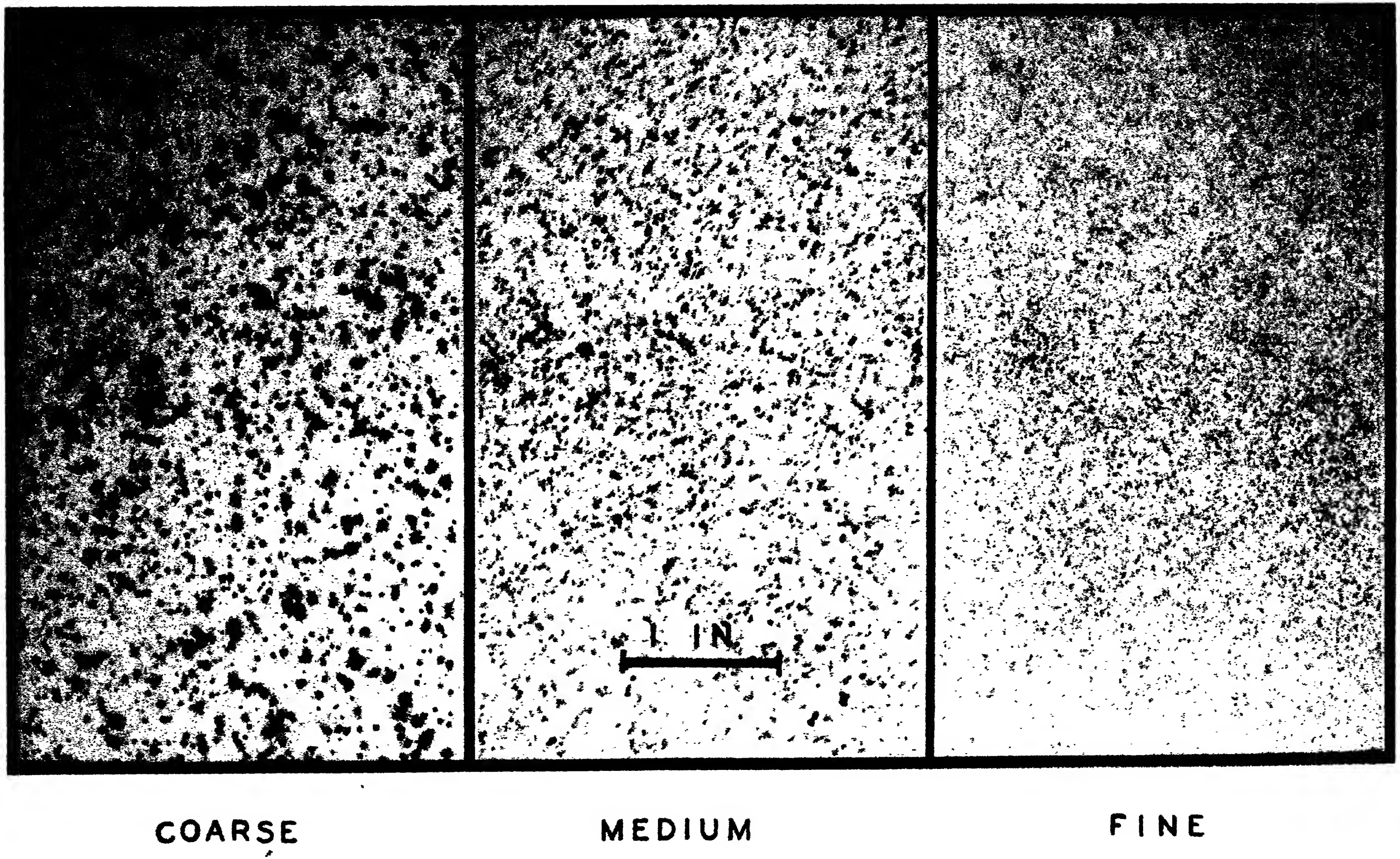


FIG. 2.—The three main degrees of atomization noted when examining the patterns.

*Symmetry.*

Good, fair, poor, bad.

*Atomization.*

Very fine, fine, medium, coarse, very coarse.

*Density.*

Well covered, heavy, light, very heavy, very light.

*Irregularities.*

None, heavier on one side, heavier in places, very heavy in parts and tending to run.

*Diameter.*

The greater the diameter the higher the marks.

Any such score card as this is open to criticism, particularly in regard to the marks awarded under each heading and sub-heading ; but until more is known regarding the exact requirements of biologists engineers must settle some standard themselves, making use of such knowledge of the various aspects of the spraying problem as they have acquired from observations in the field and information supplied by others. Having decided on the standards to be used in judging the patterns, after trying the many systems which suggested themselves, tests were applied to see to what extent different judges agreed or disagreed with one another, and it was found that these differences did not exceed $\pm 5$ per cent. It becomes a fairly easy matter after dealing with these patterns for some time to say from a superficial examination whether it is good, fair or bad, and all were divided into these three classes before the first two, good and fair, were subjected to the more detailed inspection.

Many of these patterns had been analysed and judged before the evidence produced by the next series of tests was available ; but our estimates of their qualities had to be revised to some extent after it was found that those which we thought at first were the " best " stationary patterns did not always make the best patterns when the nozzles were moved through an arc, which is somewhat similar to procedure in the field. (These latter patterns are hereinafter termed *traverse patterns.*) The marks, some of which are given in Table I, are those awarded after this later evidence had been procured. To avoid an unnecessarily large mass of figures only those variations in nozzle settings which were adjudged to give the best patterns are here included. The exposures given in these tests were one-twentieth sec., which means that every portion of the sprayed object was exposed to the spray cone for one-twentieth sec.

Nozzle A had an adjustable eddy-chamber, variable in depth, supplied through two spiral channels. The orifice was arranged in a metal *disc*, which was replaceable by others having various sized holes.

Amongst growers the terms " No. 1 disc ", " No. 2 disc " and so on are generally meant to refer to the sizes of the orifices or holes in the discs, and the same terms are used in this paper.

Nozzle B was one with no special provision for altering the depth of the eddy-chamber, but the two *vortex holes* or openings conveying the spray liquid into the chamber were variable, and different sized discs could be fitted.

Nozzle C was not fitted with adjustments for varying either the eddy-chamber or the tangential passage leading into it, but the disc orifices could be altered.

Nozzle D was similar in design to Nozzle A with like adjustments, but four channels were used, two spiral ones to produce the whirl and two straight ones.

3


FIG. 3.—An example of a disc-like pattern; produced by a nozzle having an eddy-chamber depth of 3·2 mm., a No. 1 disc orifice, 200 lb. pressure and 2 ft. 6 in. from the sprayed object.

## DISCUSSION OF RESULTS.

It became apparent at the outset that the holes in the discs of the several nozzles differed, even when new, not only in diameter, but also in circularity, centricity and angularity. For example a new No. 2 disc orifice measured 2·4 mm.,* and another

* ·4 mm. is approximately equal to $\frac{1}{64}$ in.

of the same make was 2·2 mm. in diameter. A second had a diameter of 1·05 mm. in one direction, and 1·5 mm. in another, which meant that the hole was more oval than circular. Fig. 4 shows the pattern made by an irregular disc; whereas the pattern made by a regular disc orifice was similar to Fig. 1D. Some nozzle orifices were not

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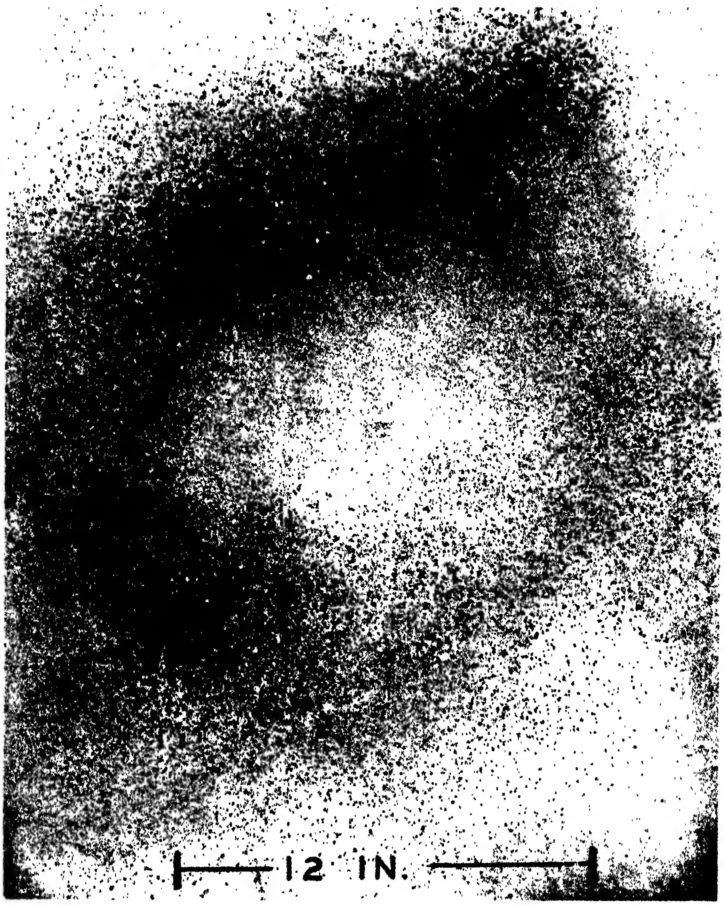


FIG. 4.—A stationary pattern showing the irregularities caused by an inaccurate disc orifice. Compare with Fig. 1D.

drilled centrally and they caused unsymmetrical patterns, such as is shown in Fig. 6. Fig. 5 shows the pattern produced by an accurate one. Yet others were found to have the holes bored askant, seeming to indicate that the drilling or piercing tool had not been held at right angles to the disc. It is the general practice for most makers to countersink one side of the disc orifice, usually the outer side, and it was found that there was even more variation in these countersinks than in the holes. Tests showed that

discrepancies in these countersunk depressions such as depth, angle and regularity, materially influenced the form of spray cone.

It was of course not possible to carry out precise tests using such irregular discs; so a set was made to very fine limits from a non-rusting metal. These were as follows:

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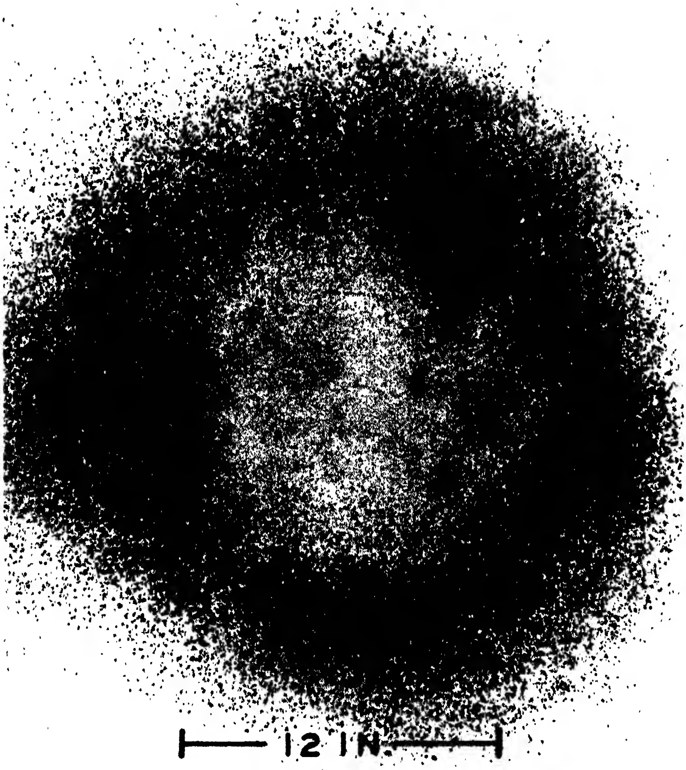


FIG. 5.—Stationary pattern made when the eddy-chamber was 3·37 mm. deep, using an accurate No. 3 disc, 100 lb. pressure and 3 ft. from the sprayed object. Compare with Fig. 6.

| | |
|---|---|
| No. 0 Disc ·75 mm., or about $\frac{1}{32}$ in. | No. 2 Disc 2·44 mm., or about $\frac{3}{32}$ in. |
| No. 1 Disc 1·4 mm., or about $\frac{1}{16}$ in. | No. 3 Disc 2·8 mm., or about $\frac{7}{64}$ in. |

To be assured that there were no minute irregularities in these special discs they were examined under the low power of the microscope, it having been determined that

even very small projections or hollows in the circumferences of orifices led to the formation of definite disturbances in the symmetry of patterns. The dimensions and general shape of these discs were examined at intervals throughout the tests.

One popular misconception to be dispelled by these researches was that smaller disc orifices produce finer sprays. They do not. They merely decrease the output.


Fig. 6.—Pattern made by the same nozzle as used for Fig. 5 with identical settings and pressure, but using a disc in which the orifice was eccentrically drilled.

The fact that this wrong impression has been so long held is perhaps due to repetition of the statement that to get fine, misty sprays No. 0 discs (one of the smallest generally used) should be used, and also due to the optical illusion that the spray in smaller quantity issuing from the nozzle was in fact a finer one. The factors which do influence the degree of atomization are pressure, depth of eddy-chamber and size of vortex holes

TABLE I.

*Some of the Marks awarded for the better " Stationary Patterns " made by various Nozzles with Diverse Settings.*

| Nozzle. | Eddy-chamber depth (mm.) or vortex holes. | Disc. | Distance. ft. in. | Pressure in lb. per sq. in. | Marks. per cent. |
|---|---|---|---|---|---|
| A | 2·6 | 0 | 1 6 | 200 | 78 |
| B | S* | 0 | 1 6 | 50 | 75 |
| C | –† | 2‡ | 1 6 | 100 | 75 |
| D | 3·7 | 0 | 1 6 | 200 | 81 |
| A | 2·6 | 1 | 1 6 | 100 | 84 |
| A | 2·6 | 2 | 1 6 | 100 | 84 |
| A | 2·6 | 2 | 1 6 | 200 | 91 |
| B | S | 0 | 1 6 | 200 | 75 |
| B | S | 1 | 1 6 | 100 | 75 |
| D | 3·7 | 0 | 2 0 | 200 | 75 |
| D | 3·7 | 1 | 1 6 | 200 | 90 |
| C | – | 2‡ | 1 6 | 200 | 78 |
| B | S | 1 | 1 6 | 200 | 78 |
| B | S | 3 | 1 6 | 50 | 75 |
| B | L | 0 | 1 6 | 50 | 78 |
| A | 2·6 | 3 | 3 0 | 200 | 75 |
| A | 2·6 | 3 | 1 6 | 50 | 81 |
| A | 2·6 | 3 | 1 6 | 100 | 84 |
| D | 3·7 | 1 | 2 6 | 200 | 84 |
| D | 3·7 | 3 | 1 6 | 200 | 93 |
| D | 3·7 | 3 | 2 6 | 200 | 84 |
| C | – | 2‡ | 2 6 | 200 | 69 |
| C | – | 2‡ | 2 6 | 100 | 63 |
| C | – | 2‡ | 1 6 | 100 | 69 |
| B | L | 1 | 1 6 | 50 | 84 |
| B | L | 1 | 1 6 | 100 | 81 |
| B | S | 2 | 1 6 | 100 | 63 |
| B | L | 2 | 2 0 | 200 | 66 |
| A | 3·37 | 1 | 1 6 | 100 | 87 |
| A | 3·37 | 2 | 2 0 | 50 | 78 |
| A | 3·37 | 3 | 4 0 | 100 | 84 |
| D | 3·9 | 2 | 2 6 | 200 | 91 |
| D | 3·9 | 3 | 2 6 | 200 | 66 |
| A | 2·6 | 1 | 2 0 | 50 | 78 |
| A | 2·6 | 2 | 2 0 | 100 | 78 |
| A | 2·6 | 2 | 2 0 | 200 | 90 |
| A | 2·6 | 3 | 2 0 | 200 | 75 |

* Nozzle B had variable vortex holes, and two settings are here noted : the small (S) which produced a wide cone of spray, and the larger (L) which made a smaller cone.

† Nozzle C had no eddy-chamber or vortex holes adjustments.

‡ Maker's discs used on this nozzle.

or channels leading into the chamber. Decreasing the eddy-chamber depth or vortex openings produces finer sprays, but decreases the output from the nozzle ; whereas increasing the pressure causes finer sprays with a greater output. It would therefore appear that the tendency to go in for higher pressures is a wise one ; but there are difficulties here, some of which are mentioned later.

The main purpose of this investigation is not to compare the various nozzles on the market, but rather to ascertain exactly what they are capable of doing ; and ultimately to suggest improvements or make completely new designs ; nevertheless it has been possible to see if any are capable of performing in a markedly superior way to others. Considered in a general way, solely from the point of view of form of spray cone, the

performances were similar. There were great differences, however, in such things as accessibility, convenience in adjusting, leakiness and so on. One of the nozzles which had adjustable vortex holes tended to throw cones which were heavier on one side than the other, which produced half-ring patterns. Some of the fixed vortex nozzles also did this, and in most of these cases the cause was traceable to unequal dimensions of the holes or channels. Increasing the depth of eddy-chambers, or increasing the size of the vortex channels in nozzles like B decreased fineness of spray and the width of the spray cones, resulting in smaller patterns, but the distance to which the spray was carried was increased. Decreasing these factors increased the fineness of the spray and the diameter of the patterns, but decreased the carry. Variations in the disc orifices contributed to alterations in the patterns: the larger the hole the greater the diameter of the cone of spray, and the greater the carry. There was also a tendency for the thickness of the rings, when ring patterns were made, to increase, but as previously noted the degree of fineness of spray was not affected.

It will be seen from Table I that only a few eddy-chamber depth or vortex hole settings are given: these were the ones which produced (i) a very wide cone with small carry, but with fine atomization and (ii) a narrower cone with greater carry, but a coarser spray. On looking at this table it will be seen that the majority of the better patterns were made at distances of less than three feet from the sprayed object. Although only a few of the results are included in this table all those not here mentioned confirm this conclusion. This does not mean, however, that none of these nozzles would not effectively carry further; but at greater distances the cones loose their symmetry due to air resistance and gravity. Maximum effective carry is commented on later. Table II includes some of the results of settings and distances which made poor patterns.

TABLE II.

*Some of the Marks awarded for the poorer "Stationary Patterns".*

| Nozzle. | Eddy-chamber depth (mm.) or vortex holes. | Disc. | Distance. ft. in. | Pressure in lb. per sq. in. | Marks. per cent. |
|---|---|---|---|---|---|
| A | 3·7 | 0 | 5 0 | 200 | 41 |
| A | 3·37 | 1 | 3 0 | 100 | 38 |
| A | 3·37 | 1 | 6 0 | 200 | 47 |
| A | 3·37 | 2 | 4 0 | 200 | 28 |
| A | 3·37 | 3 | 7 0 | 200 | 44 |
| A | 2·6 | 0 | 3 0 | 50 | 28 |
| A | 2·6 | 2 | 6 0 | 200 | 34 |
| B | S* | 0 | 4 0 | 50 | 19 |
| B | L* | 0 | 4 0 | 50 | 40 |
| B | S | 2 | 5 0 | 100 | 28 |
| B | S | 2 | 5 0 | 200 | 37 |
| B | L | 0 | 6 0 | 200 | 34 |
| B | L | 3 | 7 0 | 200 | 41 |
| B | L | 3 | 5 0 | 50 | 37 |
| C | –† | 0‡ | 1 6 | 50 | 31 |
| C | – | ·2‡ | 2 6 | 50 | 53 |
| D | 3·7 | 2 | 1 6 | 200 | 59 |
| D | 3·9 | 0 | 2 6 | 200 | 28 |
| D | 3·9 | 1 | 2 6 | 200 | 59 |

* S small vortex holes.
* L large vortex holes.
† No adjustments on this nozzle.
‡ Maker's discs.

All these tests were conducted with three pressures: 50, 100 and 200 lb. per square inch. Accurate pressure gauges were used and they were fitted on the lances immediately behind the nozzles. Very sensitive pressure regulators were not available and there was some fluctuation of the pressure gauge needles during the tests; but in most cases this was quite small at these pressures. Tests at higher pressure—up to

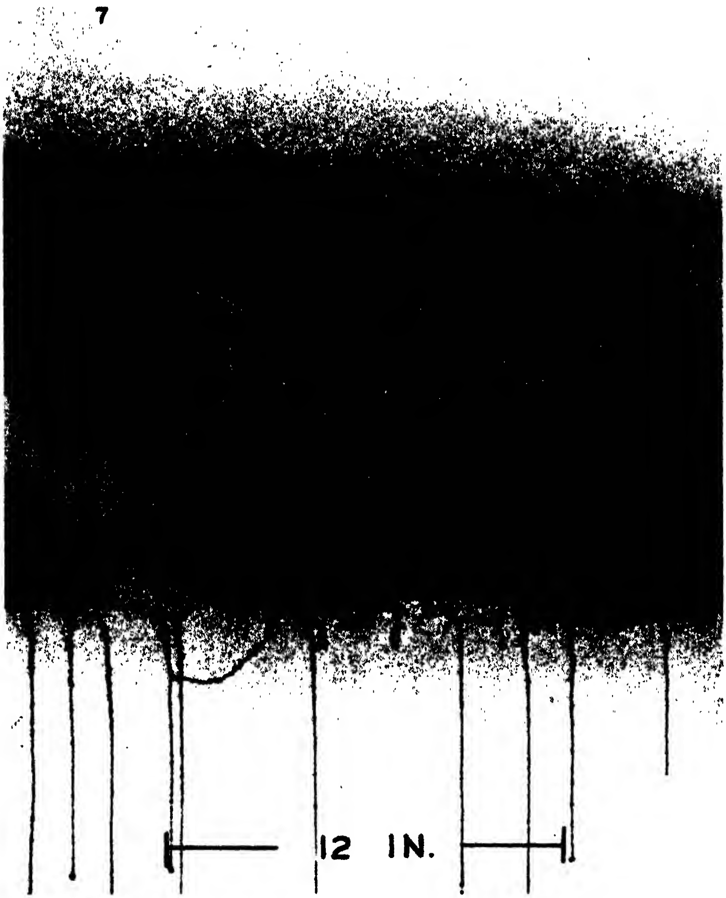


FIG. 7.—A traverse pattern made by a nozzle which had a No. 1 disc, eddy-chamber depth of 3·2 mm., 200 lb. pressure and 2 ft. 6 in. from the object. The stationary pattern obtained from these settings was disc-like in shape.

800 lb. per square inch—have been carried out and the results will be published when they have been completely analysed. Nevertheless it is possible to state that very few of the stationary patterns obtained when using pressures of 500 lb. per square inch and upwards possess much in the way of regularity; most of them were erratic splotches. Much of the changeability of these spray cones was undoubtedly due to fluctuations in

pump pressures ; but that does not preclude the probability that nozzles should be specially designed for high pressure work.

TRAVERSE PATTERNS.

The apparatus used to make the stationary patterns was modified in such a way as to enable similar lengths of exposures to be obtained when the nozzles were moved

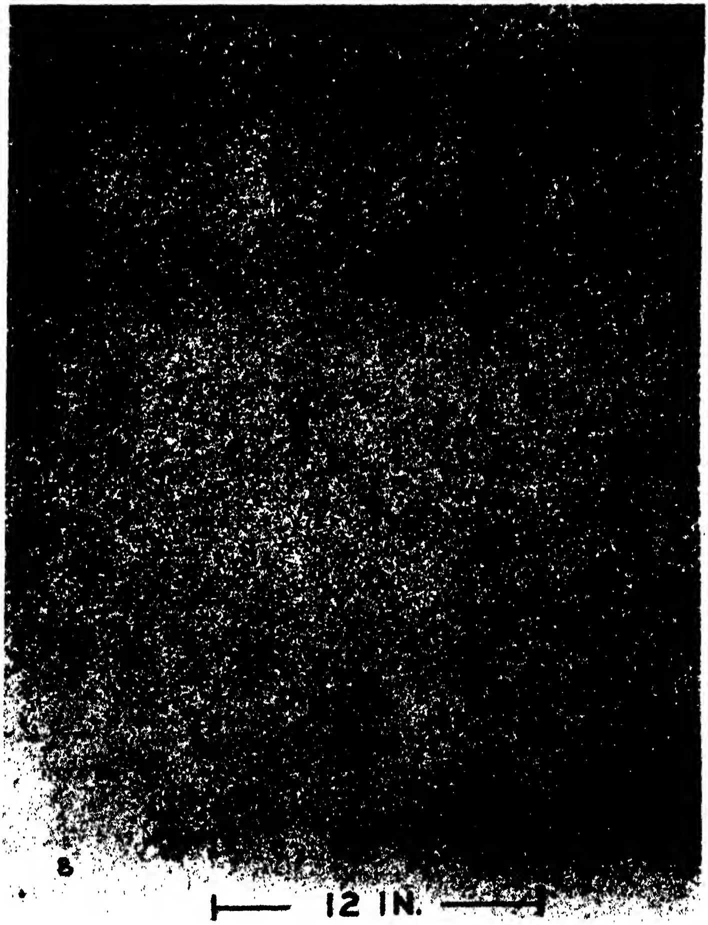


FIG. 8.—A traverse pattern made by a nozzle which had produced a ring-like stationary pattern. Disc No. 3, eddy-chamber 3 mm. deep, 100 lb. pressure and 2 ft. 6 in. from the sprayed object.

from side to side, so as to produce what are here named *traverse patterns*. The information supplied by these necessitated a revision of the views formed when the evidence of the stationary patterns alone was available. In the first place it was seen that nozzle settings which made ring-like stationary patterns produced, in many cases, very good traverses or bands of spray which were apparently not inferior to those made by filled

in disc patterns, which at first had been thought to be definitely better. Although it seems reasonable to suppose that a completely filled in cone of spray, other things being equal, is a preferable one to a hollow cone, causing a ring-like pattern, the fact remains that many of these rings did result in excellent traverse patterns. It is possible that to be truly comparable the disc producing nozzle should be traversed at a higher


FIG. 9.—A traverse pattern made by a nozzle which had produced an irregular stationary pattern. Disc No. 2, eddy-chamber 3·37 mm. deep, 200 lb. pressure and 6 ft. from the object.

speed than the ring making one, leading to more expeditious spraying. But few careful measurements have yet been taken to determine whether this is so or not, or to say whether the increased rate of working is within the capabilities of the men doing the work. So these traverse patterns were considered on their merits, judged according to the standards previously decided upon.

Figs. 7 and 8 show traverse patterns made by "solid" and hollow spray cones. The significance of symmetry and uniformity of cone was brought out in these tests, because it was invariably found that irregularities in the cones, as disclosed by the stationary patterns, were emphasized in the traverse patterns. These irregularities showed themselves in the form of poorly sprayed streaks, or as over-sprayed bands both of which are apparent on Fig. 9. It is true that the even movement of the nozzles insisted on in these tests does not fully represent the way in which nozzles and lances are "flashed" about amongst fruit trees; but that does not mean that the method employed by us in the laboratory would not be the better if a thorough cover could be obtained by it. It might be said that the thin bands would be well-sprayed in practice, because the cone of spray generally passes over the same place, from various directions, more than once. This is often true, regrettably so, but it must take longer to spray a given area if each piece has to be traversed several times. It also follows that the over-sprayed bands must be doubly or many times over-sprayed.

NOZZLE OUTPUT.

The importance of speed of working is being realized more and more by qualified advisers and progressive growers, and the measurement of output has received some attention. Wright and Woodman (1) carried out a series of tests with different settings of a nozzle, and Turnbull (2, 3, 4) keeps stressing the desirability of larger outputs, and the writers have had the pleasure of putting their services and apparatus at his disposal for the measurement of the output of various nozzles he has wished to test. Some care must be taken in designing and making instruments for the accurate determination of this factor to avoid such things as loss caused by splash, and the possible impeding effect of compressed air in a confined space and to make reasonably sure that pump pressures remain constant during tests, because, as is shown in Table III, the quantities vary considerably with pressure variations. The curves in Fig. 10 show at a glance that increases in pressure, depth of eddy-chamber, size of vortex openings and diameter of disc orifices all or individually result in increased output, which is here measured in gallons per minute.

TABLE III.

*Nozzle Output in Gallons per minute.*

| Disc. | Pressure in lb. per sq. in. 50 | 100 | 200 | 400 | 500 | 600 | Nozzle. |
|---|---|---|---|---|---|---|---|
| 0 | ·175 | ·25 | ·35 | ·5 | ·6 | ·75 | A, with eddy-chamber 2·6 mm. deep. |
| 1 | ·25 | ·35 | ·525 | ·75 | ·85 | 1·05 | |
| 2 | ·425 | ·6 | ·9 | 1·3 | 1·55 | 1·9 | |
| 3 | ·5 | ·725 | 1·05 | 1·55 | 1·8 | 2·0 | |
| 0 | ·225 | ·35 | ·5 | ·65 | ·75 | ·9 | A, with eddy-chamber 3·37 mm. deep. |
| 1 | ·35 | ·55 | ·75 | 1·1 | 1·25 | 1·5 | |
| 2 | ·75 | 1·05 | 1·375 | 2·3 | 2·5 | 2·75 | |
| 3 | ·875 | 1·275 | 1·575 | 2·5 | 2·8 | 3·4 | |
| 0 | ·175 | ·225 | ·325 | ·5 | ·6 | ·7 | B, with vortex holes set to give a wide fine cone. |
| 1 | ·25 | ·35 | ·45 | ·73 | ·9 | 1·05 | |
| 2 | ·375 | ·575 | ·75 | 1·2 | 1·5 | 1·75 | |
| 3 | ·45 | ·65 | ·9 | 1·45 | 1·85 | 2·0 | |
| 0 | ·225 | ·3 | ·4 | ·65 | ·75 | ·8 | B, with larger vortex holes. |
| 1 | ·325 | ·475 | ·6 | 1·0 | 1·2 | 1·35 | |
| 2 | ·65 | ·925 | 1·25 | 1·85 | 2·1 | 2·5 | |
| 3 | ·975 | 1·2 | 1·5 | 2·3 | 2·6 | 2·8 | |

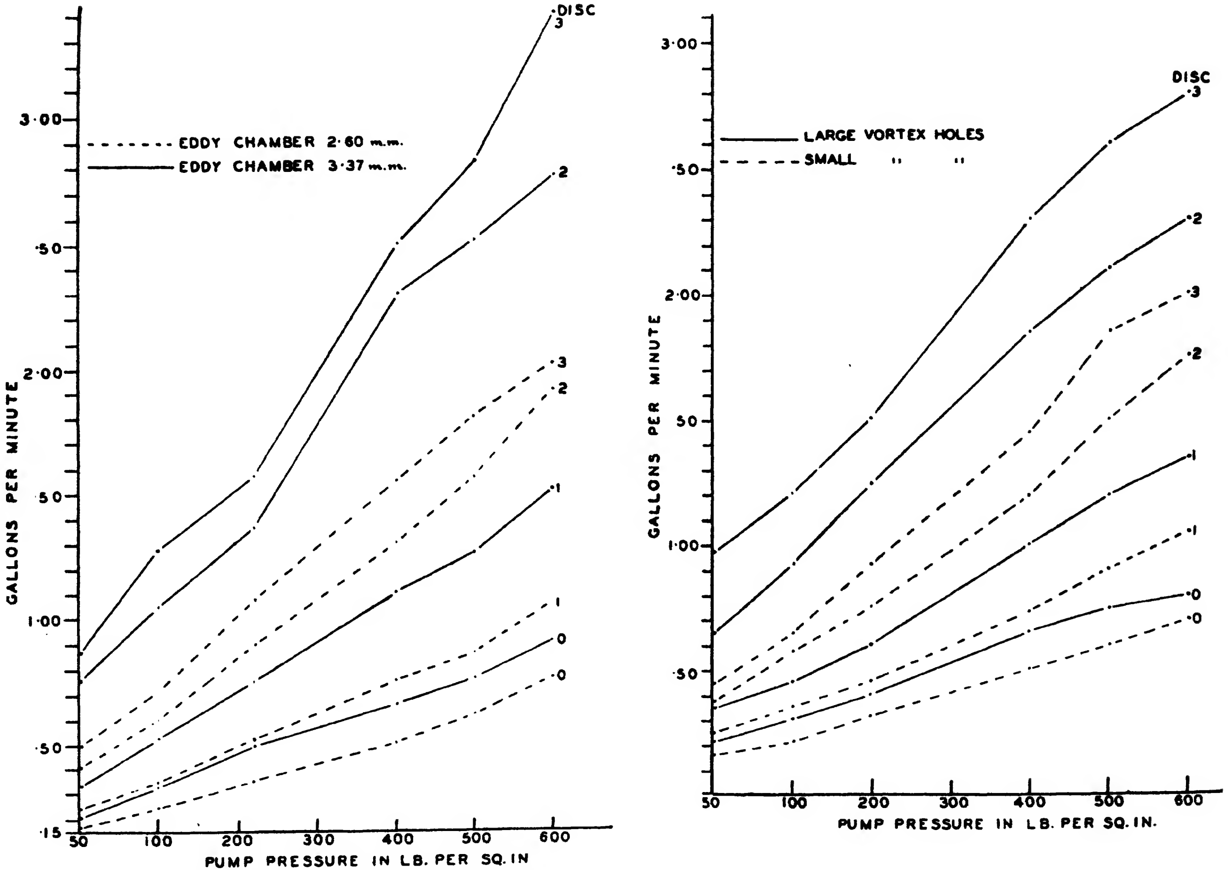


FIG. 10.—Some curves showing the variation of nozzle output with different settings and pressures.

BACK PRESSURE.

So much spraying is done with nozzles fitted to the ends of hand controlled lances, some of which are as long as ten feet, that it was thought necessary to collect data to show what back pressures had to be contended with under different conditions. Table IV shows how these back pressures increase with nozzle output, and an elementary knowledge of mechanics is sufficient to make one aware of the fact that these can be multiplied many times when the nozzle is placed at the end of a tube, or spray lance, even if one has not actually handled such a device.

TABLE IV.

*Back Pressures Generated by various Nozzles with Different Settings* (in pounds).

| Disc. | Pump Pressures in lb. per sq. in. 100 | 200 | 300 | 400 | 500 | 600 | Nozzle. |
|---|---|---|---|---|---|---|---|
| 0 | ·13 | ·23 | ·38 | ·52 | ·66 | ·78 | A, with eddy-chamber 2·6 mm. deep. |
| 1 | ·16 | ·34 | ·55 | ·8 | 1·05 | 1·22 | |
| 2 | ·3 | ·54 | ·82 | 1·1 | 1·4 | 1·65 | |
| 3 | ·38 | ·68 | 1·0 | 1·33 | 1·68 | 1·98 | |
| 0 | ·2 | ·4 | ·6 | ·8 | 1·0 | 1·2 | A, with eddy-chamber 3·37 mm. deep. |
| 1 | ·25 | ·55 | ·86 | 1·2 | 1·55 | 1·9 | |
| 2 | ·6 | 1·25 | 1·8 | 2·33 | 3·0 | 3·7 | |
| 3 | ·85 | 1·5 | 2·2 | 2·94 | 3·5 | 4·0 | |
| 0 | ·05 | ·22 | ·33 | ·44 | ·56 | ·66 | B, with vortex holes set to give a wide fine cone. |
| 1 | ·22 | ·35 | ·5 | ·65 | ·8 | 1·0 | |
| 2 | ·24 | ·5 | ·77 | 1·06 | 1·33 | 1·61 | |
| 3 | ·33 | ·66 | 1·0 | 1·27 | 1·61 | 2·05 | |
| 0 | ·28 | ·42 | ·56 | ·72 | ·9 | 1·06 | B, with larger vortex holes. |
| 1 | ·4 | ·62 | ·88 | 1·16 | 1·45 | 1·8 | |
| 2 | ·65 | 1·04 | 1·45 | 1·92 | 2·45 | 3·05 | |
| 3 | ·75 | 1·2 | 1·72 | 2·45 | 2·95 | 3·7 | |
| Approx. No. 2. | ·45 | ·7 | 1·0 | 1·3 | 1·6 | 2·0 | Twin C nozzles, as arranged by makers. |
| One nozzle cut out | ·3 | ·45 | ·6 | ·75 | ·92 | 1·05 | |
| 0 | ·2 | ·35 | ·55 | ·7 | ·9 | 1·05 | D, with eddy-chamber 3·7 mm. deep. |
| 1 | ·25 | ·6 | ·82 | 1·1 | 1·46 | 1·6 | |
| 2 | ·46 | ·92 | 1·45 | 2·0 | 2·42 | 2·95 | |
| 3 | ·7 | 1·25 | 1·7 | 2·2 | 2·7 | 3·2 | |
| 0 | ·2 | ·38 | ·56 | ·75 | ·95 | 1·2 | D, with eddy-chamber 3·9 mm. deep. |
| 1 | ·3 | ·6 | ·95 | 1·3 | 1·55 | 1·85 | |
| 2 | ·6 | 1·25 | 1·95 | 2·6 | 2·85 | 3·4 | |
| 3 | ·96 | 1·7 | 2·5 | 3·15 | 4·0 | 4·75 | |
| 0 | ·1 | ·3 | ·5 | ·7 | ·9 | 1·1 | D, with two straight vortex holes closed. Eddy - chamber 3·9 mm. |
| 1 | ·3 | ·6 | ·9 | 1·15 | 1·45 | 1·7 | |
| 2 | ·56 | 1·05 | 1·59 | 2·15 | 2·7 | 3·3 | |
| 3 | ·7 | 1·35 | 1·9 | 2·66 | 3·55 | 4·05 | |

Fig. 11 shows in graph form some of the increases in back pressure when the quantities of spray ejected are increased. It will be seen that any factor which contributes to greater output increases the back pressure. Under some present day

spraying conditions this would seem to weigh against the extended use of higher pressure spraying plant, but the introduction of fresh ideas should generally be accompanied by the use of modified or completely new methods and/or appliances. For example, the use of pressures of 400 lb. or so will often cause extensive leaks in hoses, couplings and other parts—perhaps even bursts—if these have been designed in the first instance for no more than, say, 200 lb. Many couplings, unions and washers not made for the

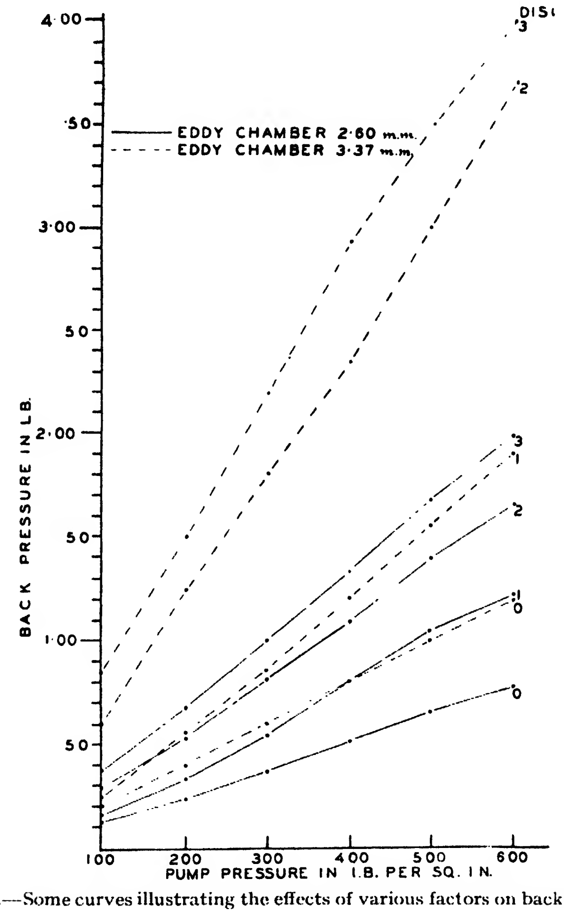


FIG. 11.—Some curves illustrating the effects of various factors on back pressure.

higher pressures are apt to be very unsatisfactory if they are relied on to deal with them. Ignoring the disadvantages of higher back pressures it is clear that many advantages accrue from the use of greater pressures than are customary to-day, providing the machinery is designed for the increased stresses.

EFFECTIVE CARRY.

Although, as stated above, the symmetry of spray cones becomes disturbed or completely destroyed at distances exceeding, in most cases, about 3 ft. it does not

follow that it is impossible to carry the spray farther than this and get some kind of cover; but the form of pattern made is very irregular and inconstant. Some of the spray falls to the ground and some of it drifts in various directions. The coarser spray cones are, it is true, atomized to a finer extent by air resistance, and in many cases the "drift" does find its way to objects which require the spray, but this is of course purely accidental. In these observations the carry was measured to that point where 75 per cent. (estimated) of the spray was reaching the object, the spray being directed horizontally. Windless conditions prevailed in the laboratory; so these measurements must be regarded as maximum ones, because even light breezes—unless travelling in the same direction as the spray—reduce the effective carry. Some of the information obtained from these tests is summarized in Fig. 12, from which it will be seen that all those factors governing nozzle-output have a direct bearing on carry: greater pressures,

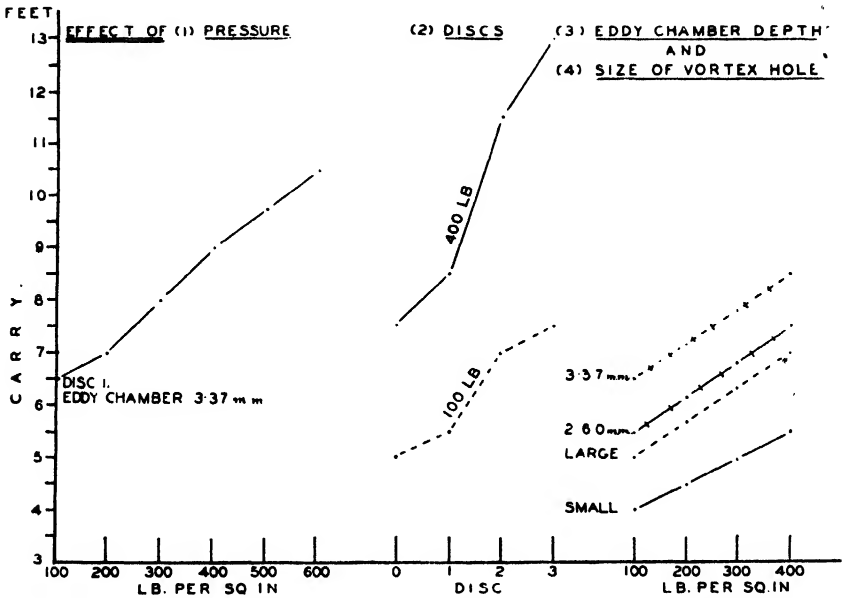


FIG. 12.—Curves showing some of the factors which control spray carry.

depth of eddy-chambers, diameter of disc holes and sizes of vortex openings all, severally and collectively, result in longer carry. The many devices used to reach distant branches and leaves—such as long lances, spraying towers, spray guns, etc.—more than suggest that carry is as important as correct atomization and quantity. The arrangements on adjustable nozzles which admit of wide fine cones of short carry and narrower coarser ones with increased reaching powers are satisfactory only up to a point; because whereas the former might be effective and expeditious for the closer branches the narrow driving cones cannot cover a given area with the same speed, on account of their very narrowness. Here again higher pressures help to simplify this problem, but they do not solve it. Combinations of higher pressures and multiple nozzles have been reported on favourably, but as yet no accurate figures are available and no work has been done here, up to the present, to ascertain the effects of the employment of more than one nozzle per lance. The fact remains that the nozzle, gun or other

contrivance which is capable of carrying a reasonably fine spray to the top of the taller trees in a wide enough cone to render the spraying operation as rapid and efficacious as is possible with objects only a foot or two away has yet to be made.

ACKNOWLEDGEMENTS.

We wish to place on record our thanks to all those Research Officers of this area who have given us advice on those aspects of pest control which are beyond our sphere; to those manufacturers and agents who have co-operated with us in loaning spraying machines and nozzles, particularly Messrs. W. Weeks & Son, Ltd., who put a high pressure power outfit at our disposal, which enabled us to obtain a great deal of valuable information, and Messrs. Cooper, Pegler & Co., Ltd., who sent us a collection of hand operated machines; to various colleagues who made valuable suggestions concerning the methods adopted to analyse the great mass of results obtained, and to those growers who kindly allowed us to make observations during their spraying times. To R. Smith, the writers' laboratory assistant, thanks are also due for his careful handling and observation of stop watches, pressure gauges and other instruments and apparatus used in the tests.

## SUMMARY OF RESULTS.

*Disc Orifices.*

1. Variations in diameter affected:
   (*a*) the diameter of spray cones: the smaller the hole the smaller the cone;
   (*b*) carry: the smaller the hole the less the carry;
   (*c*) to some extent the thickness of the ring-like patterns.

2. Variations in diameter had no effect on atomization.

3. Irregularities in the shape of disc orifices adversely affected the form of spray cones.

4. Irregularities in the countersunk portion of the discs adversely affected the spray cones.

5. Increases in the thickness of the discs decreased the diameter of the cones and decreased the atomization.

*Pump Pressures.*

6. Increases in pressure increased:
   (*a*) the atomization;
   (*b*) the carry;
   (*c*) the back pressure.

7. Increases in pressure altered the diameters of the cones.

*Eddy-chamber Depths.*

8. Increases in depth:
   (*a*) increased carry;
   (*b*) increased output;
   (*c*) increased back pressure;
   (*d*) decreased atomization;
   (*e*) decreased diameter of the spray cones.

*Vortex openings.*

9. Increases in size of vortex openings, whether holes or channels:

(*a*) increased carry;
(*b*) increased output;
(*c*) increased back pressure;
(*d*) decreased atomization;
(*e*) decreased diameter of cones.

10. Irregularities in the shape or disposition of vortex openings tended to produce spray patterns heavier on one side, or in parts, than the other.

*Carry.*

11. The symmetry of the spray cones was better at distances of 3 ft. and less; beyond this the stationary patterns generally lost their regular shape. (It has been observed in the field that most men when spraying with lances hold the nozzles about 2 ft. from the sprayed objects.)

12. Losses of spray liquid, caused by gravity and air resistance, occurred at distances from the nozzles which varied with variations in those factors governing carry; in the main the greater the carry the less the loss at given distances.

*High Pressures.*

13. The advantages of higher pressures (400 up to 800 lb. per square inch have been used) than are usually employed were:

(*a*) greater output;
(*b*) increased carry;
(*c*) better atomization.

14. The disadvantages were:

(*a*) increased losses due to leaks;
(*b*) breakdown of parts not designed to deal with the greater stresses.
(*c*) a loss of symmetry and uniformity in the spray cones; which seems to point to the desirability of having nozzles specially designed for high pressure work.

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# A NOTE ON INJURY CAUSED BY TWO SPECIES OF THYSANOPTERA

By S. G. Jary, B.A.,
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On 27 April, 1934, J. Berry, Esq. drew my attention to a field near Faversham, Kent, in which he had a Brussels Sprouts seed bed about an acre in extent. The germination of the seed was considerably delayed and the few seedlings which appeared above ground presented a most abnormal appearance. The cotyledons were dwarfed and somewhat thickened and their edges were curled together, in most cases quite tightly, forming a hollow sphere. Inside the cavity thus formed were large numbers of Thrips, all brachypterous individuals. These were kindly identified by Dr. G. D. Morison, Marischal College, Aberdeen, as *Thrips angusticeps* Uzel. The same species also occurred in the somewhat curled leaves of *Rumex* sp. in the field. The species in question has been found in many South and Eastern counties of England and is common in some localities. Dr. Morison informed me that he is of the opinion that the insect is partial to *Cruciferæ* especially for breeding purposes.

The field in question was cropped in 1933 with barley, the stubble being broken up immediately after harvest and mustard was sown. Owing to dry weather, the mustard did not attain a height of more than about one foot and it was ploughed in during the late Autumn. Dr. Morison expressed the view that the insects had undoubtedly hibernated in the soil as nymphs and that the attack was due to these hibernated individuals.

It would seem likely therefore that under the weather conditions of the late Summer of 1933, a large population of thrips was built up on the mustard and that the attack on Brussels Sprouts seedlings arose directly from the soil hibernating nymphs. On the date when the field was examined, most of the individuals had become adult, but it seems that the damage was already done, the seedlings having been irreparably injured before they appeared through the soil. Only a very small percentage of the plants ever appeared above ground and these showed typical signs of thrips feeding punctures, in addition to which the growing point was so badly injured as to inhibit normal development.

On 10 May, 1934, Mr. G. C. Johnson, Horticultural Superintendent for East Sussex, sent me specimens of apple blossom, variety Bramley's Seedling, from Ninfield, Sussex. The flowers were in the full "pink bud" stage and would normally have opened in a few days.

The petals were slightly malformed but were markedly striped by irregular pale longitudinal areas which shaded into the normal pink coloration, somewhat suggesting a blossom bud attacked by the larva of *Anthonomous pomorum*, but not sufficiently damaged to produce the typical "capped blossom". No insects other than thrips however were found in the buds, neither was there any indication of injury by other

insects. Thrips were present in large numbers, the bases of the petals, stamens and styles all showing typical lesions produced by feeding and the injury appeared sufficiently severe to interfere with normal setting of the fruit.

The species was identified by Dr. Morison as *Taeniothrips inconsequens* Uzel, commonly known as the Pear Thrips and stated to be of considerable economic importance in America and parts of Europe. It was apparently breeding in the apple flower buds since eggs were found in the blossom stalks and larger leaf veins and nymphs, almost certainly of this species, emerged.

In this *Journal*, 1910 and 1911, Theobald made reference to similar attacks by thrips, and described damage to flowers and young fruit identical with that observed in this case. It seems that in certain seasons the insect may be of some economic importance in this country and it is not improbable that it is associated with poor setting of the fruit resulting from damage done to the flowers in the unopened bud stage, when any such injury might easily be overlooked, unless very severe.

The writer is greatly indebted to Dr. G. D. Morison for identifying the species here mentioned and for much information about their distribution.

# INSECT PESTS AND THE WEATHER IN 1933

By S. G. Jary, B.A.,
*Advisory Entomologist.*

The weather of 1933 was exceptional in many parts of the country, the outstanding feature being abnormally long periods of low rainfall with the number of sunshine hours greatly in excess of the average. If reference be made to the summary given below, compiled from meteorological data recorded at Wye, Kent, it will be observed that in this locality, between the long sunny periods, there occurred some very heavy rain and hail storms which, until the end of July, kept the rainfall up to the average figure for the period. Not until August did the total rainfall figure fall below the average, a state of affairs which, it is believed, pertained in few other parts of England. This rainfall, especially during June and July, was almost entirely accounted for by very heavy thunder showers, accompanied at times by hail. The most outstanding storm occurred on 22 June, commencing at noon. It was very local and followed a track approximately SSW. to NNE. Roads in the district were flooded and the North Downs were white with hail for an hour afterwards. Plant foliage was severely cut and apple fruitlets received hailstone marks which were still in evidence at the time of fruit picking. A precipitation of 0·73 inches was recorded at the College during the forty minutes which the storm lasted. The actual width of the storm belt was restricted, judging from observation, to about two miles. Its extremely local distribution is shown by the fact that road-tarring operations about two miles from Wye to the NW. were not affected and no appreciable rain fell there.

The observations herein recorded must therefore be viewed in relation to strictly local weather, as distinct from the general climatic characteristics of the year which might probably be regarded as uniform over the whole of southern and eastern England for the period under consideration. Further, the influence of parasites, predators, including birds and animals and disease-causing organisms, must be taken into account in estimating the effect of the weather with any great accuracy, so that in the absence of thoroughly critical observations it is clearly unwise to draw more than tentative conclusions. Wardle (1929) sums up the position as follows :—" The relation of weather to insect outbreaks is much harder to elucidate than is that of climate to insect distribution . . . the difficulty, in fact, of deciding whether rainfall or temperature abnormalities immediately preceding the outbreak have influenced it, or whether a long sequence of weather abnormalities, working over a period possibly of years, previous to the outbreak, is the cause."

More exact knowledge of the effect of weather upon insect prevalence is needed and might be of much benefit ultimately to the agriculturist, but the complexity of the situation is such that up to the present little more than a number of isolated records is available. Theobald (1927) attempted to correlate weather conditions in 1924 with the scarcity of aphides in that year and in the publications of the Ministry of Agriculture and Fisheries, 1918, 1919 and 1920–1, charts are given showing the rainfall, sunshine and temperature curves for the various meteorological divisions of the country, while

the relative prevalence of the chief insect pests is given in the text. In a similar publication, 1928, curves are given showing the relative prevalence of a few selected insect pests for the period 1918–27.

No attempt was made by the writer to compile exhaustive records of the insects noted here, and they were not subjected to intensive study with a view to ascertaining any strict relationship between their prevalence and weather conditions. In most cases they are pests of farm and garden crops or occurred upon common weeds.

Aphides and soft-bodied insects in general, such as young larvae living in unprotected situations, might be expected to show most markedly the direct and immediate influence of weather conditions. At the end of 1932 it was observed that many of the common fruit tree aphides which pass the Winter as eggs on fruit trees, were notably scarce and few eggs were to be found. Thus *Aphis pomi* de Geer., *Anuraphis roseus* Baker, *Anuraphis helichrysi* Kalt., and *Rhopalosiphum prunifoliae* Fitch., all began the year with relatively small populations. This does not necessarily mean that, in certain seasons, no serious attacks will develop ; on the contrary, given suitable conditions for reproduction, some species may increase very rapidly. Hatching of the species concerned took place normally in late March and early April, when it was again confirmed that they were few in numbers. A period of cold NE. wind with sleet and snow occurred from 17-22 April and this was followed by a month of subnormal sunshine and excess rainfall, the only such month in the period under consideration. A short period of high temperature occurred from 20-23 May when 80° F. was reached, but this was followed by three days of cold, strong N. winds. These conditions appeared to influence the rate of reproduction of the aphides to such an extent that, except on trees in sheltered positions, they became very scarce. No undue activity on the part of parasites or predators was noted which could have accounted for this scarcity. On the other hand, colonies of the Woolly Aphis of apple, *Eriosoma lanigerum* Hausm., showed signs of activity very early in the year and during May were abnormally abundant near Wye. This abundance is tentatively attributed to the lack of sunshine and rather high rainfall of that month, a theory which seemed to receive some support from subsequent observations. During July, when very hot days with over twelve hours sunshine became common, many colonies under observation showed no sign of increasing and even became smaller, and this at a time when they are usually becoming most common. It appears from observations made on a small scale, that Woolly Aphis flourishes best in rather shady conditions, for where colonies were found, they were either on suckers arising at or near the bases of the trees or were on the undersides of the branches and most frequently on the north side, that is, protected from direct sunshine. Moreover, there is some evidence that in plantations where the trees are well spaced and the branches thinned out to admit adequate light, the aphis is much less serious and persistent than on crowded trees. Numerous instances were noted where infestations on young wood especially were confined to the underside of the twigs, if these were more or less horizontal, or to the north side if they were more or less vertical. Infestations of a serious character by this aphis did occur in the area in question in 1933, and indeed it was said to be worse in parts of Kent than in 1932. It is not suggested that periods of unbroken sunshine and lack of rain will exert a very profound influence upon it, for, in many cases, the shade cast by the tree is such that the wood itself seldom receives the direct rays of the sun for any long period. Other factors may determine the location of colonies on the wood ; birds may have played some part in reducing the colonies observed, though this was never seen to occur ; again a wasp was once noted carrying off one of the insects, but wasps in general were below normal numbers in the period when observations were made.

If the prevalence of Woolly Aphis is at all influenced by climatic conditions it would seem that those conditions must be studied in a very restricted area before any correlation can be attempted.

Certain other species of aphides, *Aphis rumicis* Linn., *Macrosiphum urticae* Schrank., *Macrosiphum rubiellum* Theob. and *Macrosiphum pisi* Kalt., were under observation from May onwards. *Aphis rumicis* was common on beans and many plants but never approached epidemic proportions as is sometimes the case, and the periodic heavy rains of June appeared to prevent the effective development of colonies, which rapidly dwindled until in July only a few stragglers remained. *M. urticae*, on the other hand, was extremely abundant in mid-June, but later the colonies became affected with a fungus disease which almost completely wiped them out. *M. pisi* was also very flourishing and it has been observed by Smith (1931) that this aphis appears to be most abundant during hot, showery weather. Certainly it was one of the most numerous aphides of the year and caused much concern to growers of peas. Again *M. rubiellum* was very prevalent on cultivated blackberries, but it was not followed closely in the later Summer when it disappeared from blackberries. Theobald states that this aphis migrates to *Galium* sp. in July.

Other interesting insects of the year were the Cabbage White Butterflies, *Pieris brassicae* and *P. rapae*. The first generation of these insects in the year was abnormally large with both species, and the second generation in the year so numerous as to arouse general comment. The insects could be seen in scores in gardens and over fields of *Brassicae*. A bulletin of the South-Eastern Union of Scientific Societies (1933) shows that large swarms were seen in many parts of the country, often moving in a westerly direction, and it seems that immigration may have played a part in augmenting the numbers already present here. It was naturally anticipated that very severe attacks on *Brassicae* would result, but, although careful search was made, comparatively few eggs could be found, certainly not in the anticipated numbers, and some factor or factors would seem to have been effective in limiting oviposition. Eggs of *P. rapae* were the more common, but these either did not hatch or, if they did, the very young larvae succumbed, for an intensive search revealed only an occasional one.

Other extremely abundant insects were some species of weevils. Those which hibernate as adults do not appear to have been adversely affected by the winter weather, for *Anthonomous pomorum* and *A. rubi* were both very common. Over two inches of snow fell in single falls in both January and February during very wintry spells, and in each of these months over twenty degrees of frost were recorded. The popular supposition that severe winters are destructive to insect life would appear to be contradicted in respect of these weevils at any rate. Not only were the species above-mentioned present in at least normal numbers, but *Rhynchites aequatus* was abnormally common and did much more than the usual amount of damage to apple fruitlets. *Rhynchites coeruleus*, too, was abundant and *Otiorrhynchus sulcatus* and *O. singularis* were abnormally plentiful and destructive. In order to explain this prevalence, at least one of two assumptions must be made. Either there were abnormally large numbers produced in the previous year, so that after allowing for normal mortality large numbers still remained or, if normal numbers only were present in the previous year, the winter mortality must have been abnormally small. The great prevalence of the first brood of white butterflies, too, suggests that overwintering pupae suffered no undue mortality.

The Hop Red Spider, *Tetranychus telarius*, presents an interesting case. Hibernating in the soil, crevices in poles and such-like situations, these mites are believed to

be kept in check during the Summer if moist conditions prevail, and to be encouraged by drought. The check imposed by humid conditions probably means that either the rate of reproduction is decreased in respect of individuals or that the numbers of mites reaching maturity is diminished. It is interesting to note in this connexion that until the middle of July, the average rainfall had occurred at Wye, though, by reason of this fall occurring mainly in heavy showers, with prolonged periods of hot sunshine between, the soil itself did not remain particularly moist and could hardly be expected to retain a moist atmosphere in the hop garden. The mite was not obviously abundant until the onset of real drought conditions in August, the normal time for attacks to become most severe. It then increased enormously and assumed epidemic proportions in a few weeks. In many parts of Kent where the rainfall was definitely less than at Wye, attacks were perhaps more severe, and indeed the mite is seldom epidemic in the vicinity of Wye, perhaps because of the rather retentive soils found in most hop gardens. However, among some experimental varieties of hops, one was noted as particularly susceptible to attack. At the end of one row of this variety is an overhead water tank from which water is drawn for spray fluid preparation. There is naturally some slight leakage and splashing of water from such a tank and it was noteworthy that hills of the susceptible variety near the tank were practically free from attack, which increased in intensity as the distance from the tank increased. The local effect of the water from the tank, if such be the explanation of the comparative absence of the mite, only extended for about six yards.

## SUMMARY OF METEOROLOGICAL RECORDS, WYE, KENT.

### January–September 1933.

JANUARY.

Temperature for the month below normal with a particularly cold spell 22-28 inclusive. On the nights of 23, 27 and 28, 20° of frost recorded on the grass. Two inches of snow on night of 16. Rainfall slightly below normal for month, practically all falling in first half. Strong NE. wind during cold spell but sunshine above average.

FEBRUARY.

Mean temperature about normal; sunshine and rainfall above normal. Slight snow on 18, 19 and 23. Two and a half inches of snow on 22. N. winds prevailed 11 to 23 and on 24 there were 22° of ground frost.

MARCH.

Nearly double normal sunshine for month, a mean daily average of 6·33 hours as compared with the normal 3·94 hours. Rainfall slightly below normal and mean temperature slightly above. Rainfall mainly occurred at beginning and in middle of month.

APRIL.

Sunshine above normal and rainfall below; mean temperature slightly above average. During period 17-22 cold NE. winds with sleet and snow.

**May.**

Sunshine below normal and rainfall above. Temperature above normal, especially 20-23 when 80° F. was recorded. Strong N. wind on following three days.

**June.**

Exceptionally sunny; monthly total of 260·4 hours, with daily average of 13 hours during first nine days. Rainfall also well above normal. On 22 severe thunderstorm with rain and hail yielded 0·73 inches in forty minutes. Temperatures of over 80° F. recorded 3-7 and on only two days did maximum fall below 60° F.

**July.**

Sunshine well above normal and rainfall below. Nearly all rain fell in period 8-16. Average temperature above normal, 86° F. on 26 and 90° F. on 27.

**August.**

Hot and dry with temperatures above normal. Rainless periods 1-10 and 23-30. Less than 1 inch of rain fell in remainder of month.

**September.**

Temperature, sunshine and rainfall all above normal. 4·25 inches of rain fell 11-26.

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# INVESTIGATIONS ON THE INSECT AND ALLIED PESTS OF CULTIVATED MUSHROOMS

## II and III

By M. D. Austin and S. G. Jary,
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The present investigation, commenced some two years ago, has proceeded along three main lines :—

(*a*) A survey of the incidence of mushroom pests present on commercial beds.

(*b*) The relation of the natural fauna of the materials used in mushroom culture to the incidence of attacks, i.e. manure, casing soil, spawn, etc.

(*c*) A study of the bionomics of the pests.

In the first contribution to this series, Austin and Jary, 1933, have given an account of one species of *Sciara* (*Diptera, Mycetophilidae*) not previously recorded as a pest of cultivated mushrooms ; the present paper deals with investigations carried out on the lines indicated in (*a*) and (*b*) above.

## II

## A SURVEY OF THE INCIDENCE OF MUSHROOM PESTS PRESENT ON COMMERCIAL BEDS

*DIPTERA.*

Fam. *Mycetophilidae.*

The Mycetophilid flies or Fungus Gnats are known as some of the most serious and widespread pests of mushrooms. At least five species of the genus *Sciara* have been bred from eggs or larvae found either in mushroom beds or on the mushrooms themselves and these have been briefly recorded by Austin 1933. They are *S. fenestralis* Zett., *S. vivida* Winn., *S. auripila* Winn. and *S. agraria* Felt. In practice these species may occur together and there is a chaotic overlapping of generations. A further species, *S. umbratica* Zett. has also been bred recently from mushrooms. In 1929 Theobald recorded the species *S. annulata* Meig. as destroying mycelium in beds in Sussex and it has been possible to examine preserved material collected at that time. There is little doubt that the species then identified as *S. annulata* Meig. is the same as that now known as *S. umbratica* Zett. This is a large and distinct species which was called by Theobald the Large Black Fungus Gnat.

The general life-history and habits of the mushroom feeding species appear to be similar to those of *S. fenestralis* Zett., but detailed investigations are in progress upon them. The mode of larval attack seems to be similar in all cases but a few unusual attacks have been seen. In these the larvae worked downwards from the caps, where eggs were probably laid and made their way into the gills. The points of entrance showed as tiny discoloured spots, which developed into larger holes or cracks on the caps, and the

stalks of the mushrooms when cut showed no sign of larval tunnelling. The usual form of attack commences by larvae entering at the base of the stalk, having hatched from eggs laid at or near soil level and the stalks show obvious signs of tunnelling under these circumstances.

The amount of injury which may be caused by larvae to mycelium in the beds is not known with any degree of accuracy but Sciarid larvae have been found throughout the whole depth of beds and it is very probable that mycelium is damaged by them in such cases. In this connexion it is interesting to note that *S. fenestralis* has been bred in the laboratory through several successive generations on sterilized manure alone thereby indicating that the presence of mycelium is not necessary for the normal development of the larvae. Nevertheless, if mycelium be there, the larvae do appear to feed upon it, especially around the bases of the developing buttons, and in this way they may be responsible for the small brown stunted buttons so frequently seen where fly attacks are in progress. Such brown buttons, however, may be produced in an entirely different way, as will be shown later.

Sciarid attacks may extend over the greater part of the year; *S. fenestralis* and *S. auripila* have been recorded from January to October and where houses are heated, attacks may occur at any time.

A point of some interest has been noted in connexion with *S. fenestralis* in the laboratory. Pupae of this species were present in numbers in some casing soil taken from a badly infested bed and this soil was placed in a glass container to a depth of about three inches, many pupae being easily visible through the glass. Flies emerging from these pupae moved about in the soil, which, though not artificially compacted, was not in a loose state, and worked their way into the larger air spaces in the soil, the males especially being very active. Pairing took place in these air spaces and the females subsequently laid eggs without ever coming above the soil. This may perhaps serve to explain the occasional reported failures to control Sciarid attacks by the use of nicotine. It is unlikely, however, that under commercial conditions very large air spaces occur in the soil and manure though some must be present; the flies moreover are usually attracted to light and move toward ventilators and windows in commercial houses, whereas in the case quoted, they received light through the walls of the glass vessel, so that in practice it would seem that the adult flies attempt to get to the surface. Theobald (*loc. cit.*) states that the pupae tend to work toward the surface before the emergence of adults.

The association of Sciarid flies with a Verticillium disease of mushrooms has been noted by Ware, 1933, who mentions that spores were found attached to the legs of flies taken from diseased mushrooms. These flies habitually crawl over the beds, which tends to increase the probability of their contact with such spores.

Fam. *Phoridae.*

At least one species of this family is a serious pest of mushrooms. The one most commonly met with is *Aphiochaeta* (*Megaselia*) *albidohalteris* but another and probably distinct species, at present unidentified, has been bred in small numbers. The larvae of *A. albidohalteris* tunnel in the stalks and caps in a manner similar to Sciarid larvae and it is necessary to find the larvae in order to be certain which of these flies is responsible for the attack. Attacks by Phorid larvae occur mainly in the summer months, when they may be very severe indeed and cause a more or less complete failure of beds owing to the mycelium being destroyed and the tiny buttons honeycombed with tunnels.

Adult flies of this family are often common around manure heaps and have been taken in mushroom houses in February, but details of life-history have still to be worked

out. It is not possible at present to say when and where eggs are laid, whether on the compost soil or the growing mushrooms and efforts to induce oviposition in the laboratory upon manure and spawn have so far not met with success.

Fam. *Cecidomyidae.*

Flies of this family have not been found around manure heaps or in mushroom houses but their larvae frequently occur during the winter months on mushroom beds in vast numbers. The larvae appear in patches on the surface, usually after a watering of the beds and they may congregate on the stalks and in the gills of the mushrooms, sometimes penetrating to some depth in the tissue, but normally adhering superficially. They are pale yellow to pink in colour and may not be easily visible on the mushrooms themselves even though present in large numbers. They become partially buried in the skin, giving it a streaky or stringy appearance and the presence of numerous larvae detracts from the value of the mushrooms, even if no great damage is done otherwise. Even when congregated on the surface of the beds they are not readily killed by the usual insecticidal applications.

One species of this family, *Mycophila speyeri* Barnes, has been recorded as feeding upon mycelium by Speyer, 1927, and there is some evidence that damage of this nature normally occurs since attacked beds often fail to crop well.

The larvae exhibit the phenomenon of paedogenetic reproduction to a marked degree and for this reason are very difficult to breed to the adult stage from which alone it is possible to identify the species at present. A few larvae kept under suitable conditions in the laboratory will reproduce entirely by paedogenesis until thousands of larvae are produced and no pupae or adults appear. An attempt has been made to induce pupation by allowing some of the cages in which larvae were confined, to dry out to some extent and under these conditions a very few flies have been bred but the great majority of the larvae perish without pupating. A similar case was noted by Theobald and Barnes, 1928, in larvae taken from a bed in Sussex and they also failed to obtain adults. The few bred by us have been identified by Dr. H. F. Barnes as a *Mycophila* sp., probably not *M. speyeri*.

Little is known of the life-history of these flies but it appears possible that they are part of the normal population of rotting straw, since many similar larvae can frequently be found upon the decaying leaves and straw of cereals.

*COLLEMBOLA.*

Fam. *Poduridae.*

At least one species, *Hypogastrura* (*Achorutes*) *armata* Nicolet, and its variety *inermis* is known to cause damage and many other species may frequently be found on beds. Reports of severe damage have been received mainly from the Worthing area of Sussex and in most cases shallow pits are eaten in the stalks and the edges of the caps frayed, but not materially damaged. The pits thus made superficially resemble those caused by mites, but whereas pits in which mites are feeding are moist and spongy, those caused by springtails are normally dry. This slight damage possibly occurs when other conditions are very favourable for the growth of mushrooms so that they come to maturity rapidly, for injury of a much more serious character has been observed. In this latter case the bed was also supporting a fungus invader, *Xylaria* sp., which perhaps checked the normal growth of the mushrooms. The whole of the beds in a large

glasshouse had failed to produce any crop and the only factor present other than *Xylaria* which was not universal, was the springtail attack. The normal crop of very tiny buttons had been produced in the casing soil and these were all invaded by the springtails so that very few ever grew to a height of more than half to three-quarters of an inch. Those which did grow to this height were invaded also and their growth stopped entirely. Tunnels were made in all directions in the buttons which became a dry spongy mass in which the springtails swarmed. The openings of tunnels made by this species of springtail are apparent as regular somewhat oval holes, slightly sunken. They occur either on the stalk, generally low down, some below ground, but often tunnelling commences from the cap also, especially in the larger buttons. The dry powdery condition of the attacked button serves to distinguish it from one attacked by mites; mite infested buttons are usually moist, tunnels are not formed regularly and the buttons take on a dark brown shade, whereas when attacked by springtails the discoloration is very slight. The definite entrance holes also serve to distinguish this attack from that due to fly larvae, in which the points of entrance are generally below ground and are very small, having been made by the very young larvae.

It appeared doubtful, in the beds in question, whether damage had actually been caused to the mycelium. This seemed to be very abundant and was producing numerous buttons, but the production of the crop was inhibited at this stage.

## *ACARINA.*

It is clear that certain species of mites are major pests of cultivated mushrooms and they are said to have assumed a much greater importance in the Worthing area during the past few years. In this area beds are generally put down in glasshouses for winter cropping and severe mite attacks have been observed elsewhere under similar conditions, but beds in buildings of other types may be heavily attacked also.

Mycophagous species of mites are generally found in association with predatory species and the latter being more easily seen are often suspected by growers.

The difficulty of identification, especially in the case of immature forms, appears to be considerable and it is impossible at present to give anything like a comprehensive list of the acarine fauna of mushroom beds. The most common species of mite met with so far has been *Caloglyphus kramerii* Berl. and this has occurred in several parts of the country. The species *Tyroglyphus mycophagus* and *Oppia nitens* which have been recorded as harmful to mushrooms (Ministry of Agriculture and Fisheries, Bulletin No. 34, " Mushroom Growing ") have not been recorded by us with certainty thus far.

Mites are often to be found in countless numbers as soon as, or just before beds commence to crop. The first buttons to appear on such infested beds are usually marked all over the stalks and caps with deep pits and in the case of very small buttons, these become dark brown in colour and quite hollow, though there may be no holes on the caps. In such instances entrance is effected through the stalk. Eggs of *C. kramerii* have been observed to be laid in such situations. In heavy infestations most of the crop is ruined in the button stage and few mushrooms attain to sufficient size to pick, while there is also evidence that damage is done to the mycelium as well. Mites have been found throughout the whole depth of affected beds and it seems probable that they are a normal part of the fauna of manure, especially that obtained from some sources. The actual conditions which make for a heavy infestation of manure are not known. Growers have never reported that they see numbers of mites when they are making the

compost so that, if the manure is the source of infestation, there must be a huge increase in the mite population after the beds have been made and before they commence to crop. This period is normally two to three months, which is probably sufficient, given suitable conditions, to account for the very heavy infestations which occur.

*NEMATODA.*

The presence of eelworms has frequently been observed in mushrooms which show a darkening of the caps, sometimes over the entire surface but more usually in an area near the edge. The darkening is superficial but the underlying tissues have a watery appearance. There would appear to be an association between the eelworm invasion and the " brown blotch " disease of mushrooms caused by the organism *Pseudomonas tolassi*, described by Paine, 1919. It was shown by Paine that this organism itself is capable of causing the disease and in U.S.A. Steiner, 1933, states that the eelworm *Rhabditis lambdiensis* can act as a carrier of this bacterium and is thus at any rate an agent in spreading the " brown blotch ". While it has not been shown that the same occurs in this country, it is interesting to record that *Rhabditis teres* Schnr., a closely related species of eelworm to that found by Steiner to be a carrier, has been frequently found by us in mushrooms showing typical " brown blotch ". Steiner suggests that drops of water adhering to mushrooms may encourage the spread of the eelworm and advises ventilation to remove surplus moisture.

Grateful acknowledgement is made to the following for their help in identifying various insects, eelworms and mites: Dr. O. W. Richards, Dr. H. F. Barnes, Dr. F. W. Edwards, Dr. W. Maldwyn Davies, Dr. T. Goodey, Dr. S. Finnegan and Mr. A. M. Massee.

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## III

## THE NATURAL FAUNA OF STABLE MANURE USED IN THE PREPARATION OF MUSHROOM BEDS

In a study of the pests which attack cultivated mushrooms it is clearly important to know by what means the animals in question gain access to the beds. Although beds may be prepared in buildings of various types, it seems unlikely that the heavy infestations which occur in some of them can be explained by supposing that the pests in question gain an entrance after the beds are made, though this possibility must not be

overlooked. The beds may remain *in situ* and undisturbed except for slight watering for six months or more and there is a reasonable time for large populations of some insects and mites to arise from a few original immigrants. However, it is not unnaturally supposed by growers in general that most of the pests are actually introduced into the houses in some way and there would appear to be three main possibilities to explain the presence of pests apart from actual immigration, (*a*) they are already present in the houses to some extent, in crevices of woodwork, soil or debris remaining from previous beds ; (*b*) they are introduced in the manure or (*c*) they are introduced in the casing soil. It is considered that the spawn as at present prepared could hardly be expected to provide a source of introduction though this may not have been the case with older types of spawn.

Of all possibilities, suspicion perhaps most naturally rests upon the manure and it was with the idea of throwing some light upon this aspect of the matter that the present investigation was commenced as soon as a local supply of manure, in the process of composting for mushroom beds, became available. The manure from which samples were taken was made in stables on the farm, removed daily and thrown into a heap in a loose box where it accumulated for a month or more until sufficient was obtained to build a heap. It was then removed into a Dutch barn, made up into suitable shape and the turning processes commenced. The first sample was taken at this stage, before turnings commenced and other samples were obtained at intervals as subsequent turnings became necessary. The periods between the taking of samples ranged from about three days to a week. After taking the first sample from the fresh manure, two samples were taken subsequently each time, one from the outside of the heap and one from the inside near the middle. The temperature was taken at the time by inserting a thermometer at the point from which the sample was later drawn. The number of samples taken depended upon the number of turnings given to the heap. Samples were at once put into bags and taken to the laboratory where they were transferred to large inverted bell-jars, the mouths of which were covered with fine muslin. Active insects and some larvae and mites quickly worked their way out of the manure and were secured. After an interval of several days, when no more insects appeared, the samples were carefully examined, all matted lumps torn to pieces and the whole of the fauna collected. Where mites were very numerous, large random samples of all forms were taken and larvae and pupae of various insects collected and the adults bred out. In some instances final examination of the samples was delayed for some weeks in order that any eggs present might hatch and the small larvae attain a sufficient size to enable them to be seen. Examination of two heaps of manure has been completed in this way and the whole of the fauna identified as recorded below. The two series represent two different heaps and the dates of sampling are given ; samples labelled A were taken from the outside of the heap and those labelled B from the inside.

The fauna of such heaps will obviously depend upon a number of factors, the chief of which may be summarized as follows :—

(*a*) the locality in which the observations are made ;

(*b*) the immediate surroundings of the heap, whether in a farm yard, glasshouse, nursery, etc. ;

(*c*) the treatment which the manure receives before the composting process is commenced, e.g. whether stored for long periods, conditions of storage affecting physical condition, whether excessively moist or dry ;

(*d*) the time of year at which observations are made ;

(*e*) the efficiency of the composting process, e.g. whether matted pieces in the manure are broken down at each turning, outer parts of the heap thrown into the middle of the new heap, etc., factors which have a bearing upon the temperature to which all parts of the heap are sooner or later subjected.

It has not been possible up to the present to examine systematically samples from localities other than Wye and therefore nothing can be said about the variation of fauna due to this factor, but data on the remaining four points has been obtained and is recorded.

In order to carry this work to its logical conclusion, the data obtained from the samples should be correlated with the incidence of pest attacks upon beds made from the sampled heaps and this is the object in view. Beds have been prepared under commercial conditions from the heaps in question, but as they are not yet cropping, data relating to pest attacks cannot be obtained.

An examination of the lists of insects and mites given below, shows a notable absence of any of the known pests of mushrooms. Among the flies a single example of the family *Phoridae* and a single specimen of the family *Mycetophilidae* have been taken, presumably "strays". The possibility that eggs or larvae of these flies may have been overlooked in the examination or that the samples were not sufficiently large to give a fair indication of the fauna, has been realized, but all reasonable precautions have been taken to reduce the chances of error in these directions to a minimum. Assuming that a fair census has been taken, and the regularity with which some species occur seems to show that this has been the case, it is tolerably certain that up to the time the mushroom beds were made the compost was free of the usual pests. If therefore attacks do eventually occur upon these beds, it is at all events known that the pests were not in the compost prior to the making of the beds. Even if no pests are present in the compost however, there is a period which occurs between the putting down of the beds and the application of the casing soil, when infestation might possibly occur. This period may be as long as a month and during that time the spawning of the beds takes place, so that, if certain insects or mites are attracted to active growing spawn, they might gain access during such a period. If this is shown not to be the case, then invasion must take place at some time subsequent to casing and before cropping commences, a period which, in the case of beds grown in unheated buildings or out of doors, may be three months or more. Should the beds made from the heaps sampled remain free from pest attacks, the data regarding the fauna of compost will be of correspondingly less value, but there are some points which suggest themselves in this connexion. In the first place, the conditions of storage of the manure at the farm in question may have some effect upon the fauna, for storage takes place under cover and the manure is not left for long periods before it is composted. Again, the fauna of the locality may be such that in any case there would be little infestation of the manure, though this is improbable, for heavy attacks of the Phorid *Aphiochaeta* (*Megaselia*) *albidohalteris* have occurred on the farm and some infestation by the Sciarid flies has been noted there. Finally, it is possible that compost made at the time of year when these samples were taken, is not normally infested and there is some evidence that this is the case, for beds made from manure composted in the late autumn and winter for early cropping in the following year are as a rule not heavily attacked. This point can only be established by observations on manure composted throughout the whole year and with this object in view it is proposed to carry on with an investigation of this nature in order to study the fluctuation of species throughout the year.

Although none of the known pests of mushrooms appeared in the samples taken, certain interesting facts are brought out in the lists of fauna. Among the Diptera, four species of the family Borboridae occur, *Sphaerocera vaporariorum* with considerable regularity. The Borborid flies are very common around manure heaps but so far their larvae have not been found in these samples nor have any flies of this family been bred by us from larvae attacking mushrooms. Since this was written, the larvae of the Borborid species *Sphaerocera subsultans* has been taken commonly in samples of manure from later series, the fauna of which is not recorded in this paper. The absence of Borborid larvae from the series recorded therefore appears to be attributable to the time of year when the heaps were made. The Sciarid species, *S. auripila* was a male and this species is one of the common mushroom infesting flies. The Phorid was a badly damaged specimen, the identity of which could not be established with certainty. The regularity with which the common fly *Stomoxys calcitrans* appears was perhaps to be expected. In every case this species was taken as a larva or pupa and bred out, but they appeared to be able to survive in the interior parts of the heaps where temperatures ranged as high as 53° C. The abundance of *Coleoptera* again might have been anticipated and many dung-inhabiting species were present. *Anthicus floralis* was regularly taken in some numbers and showed some signs of preference for the warmer parts of the heap. A general falling off in numbers of both *Diptera* and *Coleoptera* is noticeable with the increasing age of the compost and the second heap, commenced on 20 November, shows fewer individuals than the first, commenced on 26 October. The acarine fauna consists entirely of a few species of the *Parasitidae*. The relative numbers of these in the various samples of the two series cannot be indicated as no accurate census was taken. It is sufficient to note that no known mycophagous species were recorded.

Grateful acknowledgement is made to Mr. C. T. Gimingham, Mr. J. H. Stapley and Mr. R. S. Pitcher for assistance with the *Coleoptera*, to Dr. O. W. Richards for naming some of the *Diptera* and to Dr. S. Finnegan for naming the mites.

## SERIES I

26 October 1933.

Sample 1a. Outside of heap. 51·8 F (11·0 C).
Finally examined 17 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Leptocera ferruginata* Stenh.
*L. heteroneura* Hal.
*Megaselia* (*Aphiochaeta*) sp.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Sphaeridium bipustulatum* F.
*Leptacinus parumpunctatus* Gyll.
*L. linearis* Gr.
*Anthicus floralis* L.
*Cercyon pygmaeus* Ill.
*Metabletus truncatellus* L.
*Philonthus ventralis* Gr.

*ACARINA :*

*Macrocheles vagabundus* Berlese.
*Parasitus* sp. nymphal forms.

Sample 1b. Inside of heap. 109·4 F (43·0 C). Finally examined 17 November.

*DIPTERA :*

*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Hister bimaculatus* L.
*Carcinops quatuordecemstriata* Steph.
*Myrmecoxenus vaporariorum* Guer.
*Sphaeridium bipustulatum* F.
*Cercyon terminatus* Man.
*C. nigriceps* Marsh.
*Anthicus floralis* L.
*Leptacinus parumpunctatus* Gyll.
*Philonthus ventralis* Gr.

*ACARINA :*

*Parasitus* sp. nymphal forms.
*Chelifer nodosus* Schrank.

30 October 1933.
Sample 2a. Outside of heap. 51·8 F (11·0 C). Finally examined 18 November.

*DIPTERA :*

*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Anthicus floralis* L.
*Leptacinus parumpunctatus* Gyll.
*Sphaeridium bipustulatum* F.
*Hister bimaculatus* L.
*Cercyon pygmaeus* Ill.
*Atheta harwoodi* Williams.

*DERMAPTERA :*

*Labia minor.*

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

Sample 2b. Inside of heap. 118·4 F (48·0 C). Finally examined 18 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Sphaeridium bipustulatum* F.
*Hister bimaculatus* L.
*Cercyon terminatus* Man.
*C. pygmaeus* Ill.
*Anthicus floralis* L.
*Leptacinus parumpunctatus* Gyll.
*Philonthus ventralis* Gr.
*Monotoma spinicollis* Aub.

*DERMAPTERA :*

*Labia minor.*

*CRUSTACEA :*

*Oniscus asellus* L.

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

1 November 1933. (Material not turned since last sampling.)
Sample 3a. Outside of heap. 49·1 F (9·5 C).
Finally examined 21 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Sphaeridium bipustulatum* F.
*Cercyon pygmaeus* Ill.
*C. nigriceps* Marsh.
*Leptacinus parumpunctatus* Gyll.
*Philonthus ventralis* Gr.

*ACARINA :*

*Parasitus* sp. nymphal forms.

Sample 3b. Inside of heap. 131·0 F (55·0 C).
Finally examined 21 November.

*DIPTERA :*

*Sciara auripila* Winn.
*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Anthicus floralis* L.
*Hister bimaculatus* L.
*Sphaeridium bipustulatum* F.
*Cercyon terminatus* Man.
*Monotoma spinicollis* Aub.
*M. picipes* Herbst.
*? Cryptophagus pallidus* Stm.
*Myrmecoxenus vaporariorum* Guer.
*Lithocharis ochracea* Gr.

*CRUSTACEA :*

*Oniscus asellus* L.

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

6 November 1933.
Sample 4a. Outside of heap. 50·0 F (10·0 C).
Finally examined 27 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Anthicus floralis* L.
*Monotoma spinicollis* Aub.
*Leptacinus linearis* Gr.

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

Sample 4b. Inside of heap. 127·4 F (53·0 C).
Finally examined 28 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Leptocera heteroneura* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Philonthus ventralis* Gr.
*Anthicus floralis* L.
*Cercyon pygmaeus* Ill.
*Monotoma spinicollis* Aub.
*Lithocharis ochracae* Gr.

*CRUSTACEA :*

*Oniscus asellus* L.

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

9 November 1933.
Sample 5a. Outside of heap. 49·1 F (9·5 C).
Finally examined 29 November.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Monotoma spinicollis* Aub.
*Hister bimaculatus* L.

*ACARINA :*

Sample 5b. Inside of heap. 125·6 F (52·0 C).
Finally examined 29 November.

*DIPTERA :*

*Stomoxys calcitrans* L.

*ACARINA :*

*Macrocheles vagabundus.*
*Macrocheles vagabundus* nymphal forms.
*Parasitus* sp. nymphal forms.

## SERIES II

20 November 1933.
Sample 1a. Outside of heap. 40·0 F (4·4 C).
Finally examined 4 December.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Leptocera ferruginata* Stenh.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Anthicus floralis* L.
*Lithocharis ochracea* Gr.

*COLLEMBOLA :*

*Hypogastrura* sp.

*DERMAPTERA :*

*Labia minor.*

*ACARINA :*

*Pergamasus crassipes* L.
*Parasitus* sp. nymphal forms.
*Chelifer nodosus.*

Sample 1b. Inside of heap. 140·0 F (60·0 C).
Finally examined 4 December.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*Leptocera ferruginata* Stenh.

*COLEOPTERA :*

*Anthicus floralis* L.
*Monotoma spinicollis* Aub.
*Cercyon pygmaeus* Ill.

*ACARINA :*

*Parasitus* sp. nymphal forms.

23 November 1933.
Sample 2a. Outside of heap. 50·9 F (10·0 C).
Finally examined 5 December.

*DIPTERA :*

*Sphaerocera vaporariorum* Hal.
*S. subsultans* L.
*Leptocera ferruginata* Stenh.
*L. puerula* Rdi.
*Stomoxys calcitrans* L.

*COLEOPTERA :*

*Philonthus ventralis* Gr.
*Ph. addendus* Shp.
*Sphaeridium bipustulatum* F.
*Cercyon pygmaeus* Ill.

*DERMAPTERA :*

*Labia minor.*

*ACARINA :*

*Macrocheles vagabundus.*
*Parasitus* sp. nymphal forms.

Sample 2b. Inside of heap. 149·0 F (65·0 C).
Finally examined 5 December.

*COLEOPTERA :*

*Anthicus floralis* L.

28 November 1933.
Sample 3a. Outside of heap. 52·7 F (11·5 C).
Finally examined 6 December.

*DIPTERA :*

*Leptocera ferruginata* Stenh.
*Sphaerocera vaporariorum* Hal.
*Stomoxys calcitrans* L.

*ACARINA :*

*Pergamasus crassipes.*
*Parasitus* sp. nymphal forms.

Sample 3b. Inside of heap. 131·0 F (55·0 C).
Finally examined 6 December.

NO FAUNA.

1 December 1933.
Sample 4a. Outside of heap. 50·9 F (10·5 C).
Finally examined 7 December.

NO FAUNA.

Sample 4b. Inside of heap. 149·9 F (65·5 C).
Finally examined 7 December.

*DIPTERA :*

*Leptocera ferruginata* Stenh.

7 December 1933.
Sample 5a. Outside of heap. 43·7 F (6·5 C).
Finally examined 13 December.

NO FAUNA.

Sample 5b. Inside of heap. 154·4 F (68·0 C).
Finally examined 13 December.

NO FAUNA.

11 December 1933.
Sample 6a. Outside of heap. 43·7 F (6·5 C).
Finally examined 17 December.

*DIPTERA :*

*Leptocera ferruginata* Stenh.

*ACARINA :*

*Macrochele vagabundus.*
*Parasitus* sp. nymphal forms.

Sample 6b. Inside of heap. 149·0 F (65·0 C).
Finally examined 17 December.

NO FAUNA.

| Sample | Sphaerocera vaporariorum | S. subsultans | Leptocera ferruginata | L. heteroneura | L. puerula | Sciara auripila | Megaselia [Aphiochaeta] sp. | Stomoxys calcitrans | Macrocheles vagabundus | Pergamasus crassipes | Parasitus sp. [nymphal forms] | Sphaeridium bipustulatum | Leptacinus parumpunctatus | L. linearis | Anthicus floralis | Cercyon pygmaeus | C. nigriceps | C. terminatus | Metabletus truncatellus | Philonthus ventralis | P. uddendus | Hister bimaculatus | Carcinops quatuordecemstriata | Myrmecoxenus vaporariorum | Atheta harwoodi | Monotoma spinicollis | M. picipes | Lithocharis ochracea | Cryptophagus pallidus |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Series 1.** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1a | 3 | . | 8 | 1 | . | . | 1 | 10 | P | a | P | 3 | 2 | 1 | 2 | 1 | . | . | 1 | 1 | . | . | . | . | . | . | . | . | . |
| 1b | . | . | . | . | . | . | . | 5 | a | a | P | 2 | 1 | . | 13 | . | 1 | 2 | . | 1 | . | 3 | 1 | 2 | . | . | . | . | . |
| 2a | . | . | . | . | . | . | . | 20 | P | a | P | 3 | 3 | . | 3 | 4 | . | . | . | . | . | 3 | . | . | 1 | . | . | . | . |
| 2b | 9 | . | . | . | . | . | . | 10 | P | a | P | 2 | 4 | . | 11 | 1 | . | 1 | . | 2 | . | 4 | . | . | . | 1 | . | . | . |
| 3a | 4 | . | . | . | . | . | . | 5 | a | a | P | 5 | 4 | . | . | 2 | 1 | . | . | 2 | . | . | . | . | . | . | . | . | . |
| 3b | 5 | . | . | . | . | 1 | . | 5 | P | a | P | 1 | . | . | 7 | . | . | 1 | . | . | . | 1 | . | 1 | . | 3 | 1 | 1 | 1 |
| 4a | 3 | . | . | . | . | . | . | 6 | P | a | P | . | . | 1 | 3 | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . |
| 4b | 10 | . | . | 1 | . | . | . | 4 | P | a | P | . | . | . | 9 | 2 | . | . | . | 4 | . | . | . | . | . | 7 | . | 1 | . |
| 5a | 3 | . | . | . | . | . | . | 3 | a | a | a | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | 2 | . | . | . |
| 5b | . | . | . | . | . | . | . | 4 | P | a | P | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Series 2.** | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| 1a | 3 | . | 3 | . | . | . | . | 1 | a | P | P | . | . | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . |
| 1b | 4 | . | 2 | . | . | . | . | . | a | a | P | . | . | . | 3 | 1 | . | . | . | . | . | . | . | . | . | 1 | . | . | . |
| 2a | 2 | 1 | 2 | . | 1 | . | . | 3 | P | a | P | 2 | . | . | . | 2 | . | . | . | 12 | 1 | . | . | . | . | . | . | . | . |
| 2b | . | . | . | . | . | . | . | . | a | a | a | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 3a | 1 | . | 2 | . | . | . | . | 1 | a | P | P | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 3b | . | . | . | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 4a | . | . | . | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 4b | . | . | 1 | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 5a | . | . | . | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 5b | . | . | . | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 6a | . | . | 1 | . | . | . | . | . | P | a | P | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 6b | . | . | . | . | . | . | . | . | a | a | a | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

In the case of the Mites P indicates present, a indicates absent.

*Tabulation of Species occurring in the foregoing list.*

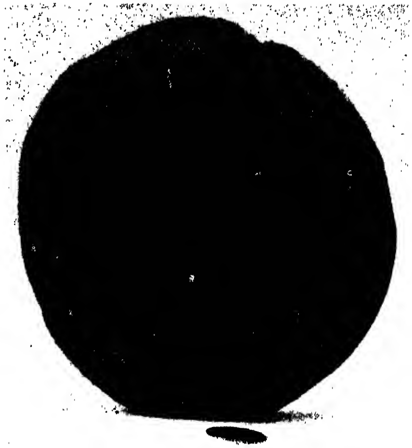
*Caloglyphus kramerii.* Deep pits in cap and stalk caused by the mite.

Pits in the cap caused by *C. kramerii.*

Section of mature mushroom showing tunnelling by larvae of *A. albidohalteris.*

*Aphiochaeta* (*Megaselia*) *albidohalteris.* Longitudinal section of button tunnelled by the larvae.

*Hypogastrura armata*. Mature mushroom showing injury to the stalk.



Cap of mature mushroom showing entrance to tunnels made by *H. armata*.

Attack by *H. armata* on button stage of mushroom.

Shallow pits in stalk and frayed edges of cap, the usual slight injury caused by *H. armata*.

Section of button showing tunnels made by *H. armata*.

# THE APPLE FRUIT MINER (*ARGYRESTHIA CONJUGELLA* ZELL.)

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## Introduction.

The genus *Argyresthia* Hübn. of the family *Tineidae* is represented by shoot-boring moths of no economic importance. There are, however, three species which are exceptions to this habit and known to be pests of fruit. They are the Cherry Blossom Moth (*A. ephippiella* Fabr.), the Cherry Fruit Moth (*A. nitidella* Fabr.) and the Apple Fruit Miner (*A. conjugella* Zell.).

The Apple Fruit Miner has been known as a pest of apples in England since 1897, when it was recorded damaging fruit in Devonshire (Warburton, 1898). In 1911 it was again found in Devonshire and, in the same year, in Cumberland (Theobald, 1911). An outbreak of the pest occurred in Scotland in 1926 causing considerable damage to the apple crop over an extensive area (MacDougall, 1926), and in the same year it appeared in Northumberland and Westmorland (Fryer, 1926).

Although the moth is well distributed and not uncommon throughout Great Britain and Northern Ireland (Meyrick, 1927), it has apparently not been recorded as a primary pest in any of the important fruit-growing districts. It has, however, caused considerable damage in a localized area near Canterbury in Kent during the last few years. Abroad it is an important pest in many countries, especially in Japan, Manchuria, Russia, Germany, Denmark, Norway, Sweden and Canada.

The life-history of the moth as it occurs in this country has not been completely worked out, previous accounts having been based mainly on observations by workers abroad. The following account is compiled from observations on the moth near Canterbury during the period 1932-4.

## Description of the Moth.

The moth is a small, frail insect about 5 mm. in length with a wing expanse of 12 mm. The head is white and the fore-wings a dark purple but with a series of very short diagonal white marks along the costal margins. Along the anal margin of the fore-wing is a broad white streak which is interrupted in the middle by a dark transverse band. The hind-wings are of a uniform grey colour and are fringed with long hair of the same colour. The antennae are as long as the body and are composed of thirty-six segments with a scape equal in length to four segments. The proboscis is two-thirds as long as the antenna and on each side of it is a prominent labial palp of four segments.

## The Life-History.

The normal host of the Apple Fruit Miner is the Mountain Ash or Rowan Tree (*Pyrus* (*Sorbus*) *aucuparia*) on which the life-cycle proceeds in the following manner.

The moths emerge from pupation in the early summer and lay eggs on the young green mountain ash berries. When the eggs hatch the larvae burrow into the berries and remain there until they are full-fed. They then leave the berries and pass the winter as pupae in cocoons. The following dates were noted concerning the activities

of the pest on mountain ash during 1933. The moths commenced to emerge on 30 May and were last seen on 6 July, giving a flight period of approximately six weeks. Oviposition lasted from 8 June to 24 June, a period between two and three weeks in length. The incubation period of the eggs was thirteen days. The duration of the larval life was variable but the minimum period required by the larva to become full-fed was five weeks.

## Description of the Immature Stages.

*The Egg.* The egg is creamy-white in colour with the surface coarsely granulated. It is oval in outline but somewhat flattened, its greatest width being 0·3 mm. and length 0·7 mm.

*The Larva.* The larva on hatching from the egg is pale yellow in colour with a black head. It is no more than 0·8 mm. in length. The pro-thoracic segment and the last two segments of the abdomen bear dark patches on the dorsal surface.

The larva increases in size until it attains a length of 6 mm. As it becomes full-fed it often assumes a pink colour but this is not always the case for it sometimes remains pale yellow. The dark patches on the pro-thoracic and the last two abdominal segments persist. The number of instars was not determined, but there are probably three. Head-capsule measurements were made and could be arranged in three groups but did not seem to obey Dyar's Law of the geometrical increase in the breadth of the head-capsule for successive instars, with any marked precision.

*The Pupa.* The pupa is about 5 mm. in length and brown in colour. No spines or setae, other than those associated with the cremaster, exist on the surface, which is completely smooth. Pupation takes place in a closely spun cocoon which is itself enclosed in a larger loosely woven net.

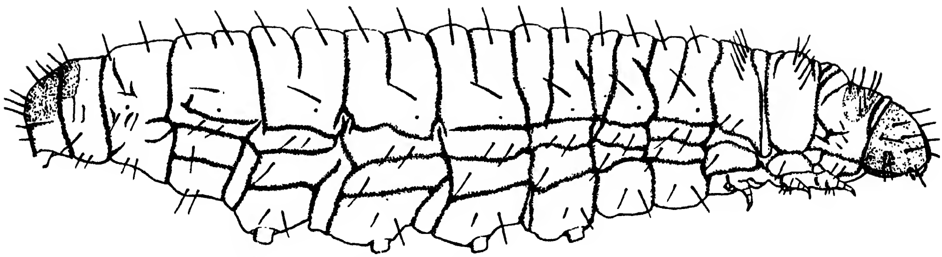
## *Field and Laboratory Observations.*

*Appearance of moths in the field.* In the year 1933 adults were first seen in the field on 30 May round about mountain ash trees. They became very common two weeks later, especially on 14 June when a large number was collected for breeding in the laboratory. The moths evidently did not fly readily for they could often be seen resting on the foliage and trunks of mountain ash trees and others near by, flying only when disturbed. The moth, in resting, assumes a characteristic pose with the hinder end of the body tilted obliquely up from the surface on which the moth is resting, so that it appears almost to be standing on its head. The moth eventually became less common and after 6 July could not be found in the field.

The sexes could not be distinguished in the field and only with difficulty in the laboratory.

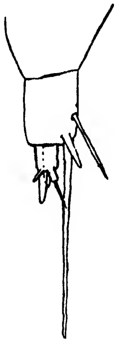
*Oviposition.* Eggs were found in the field on 8 June on mountain ash berries, eight days after the first appearance of the adults, and were last seen on 24 June. Oviposition was never witnessed in the field but was observed in the laboratory on several occasions.

Egg-laying was studied in the laboratory by confining moths, collected by beating on mountain ash trees, over a twig of apple with several fruits, embedded in a pot of damp sand and covered by a glass cylinder closed at the top with cellophane. On these apples moths readily oviposited, large numbers of eggs being deposited on single apples, as many as forty being counted on one occasion; the number laid by an individual female, however, was about twenty-five. When such large numbers were laid on a single fruit mortality was often high, sometimes 40 per cent. of the ova failing to hatch.

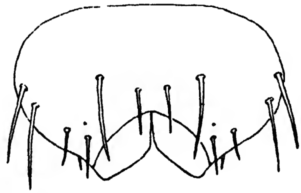


Mature larva of *A. conjugella* approximately x 22.

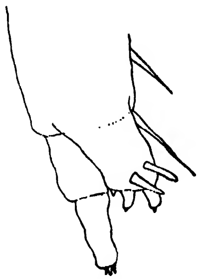
ANTENNA AND MOUTH-PARTS OF MATURE LARVA OF *A. conjugella* AND PUPA OF *A. conjugella*.



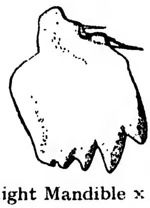
Left Antenna x 200.



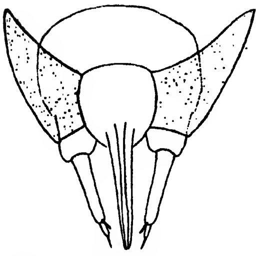
Dorsal view of Labrum x 250.



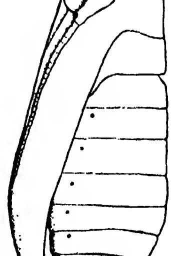
Distal portion of right Maxilla x 250.



Right Mandible x 150.



Distal portion of Labium, ventral view x 500.



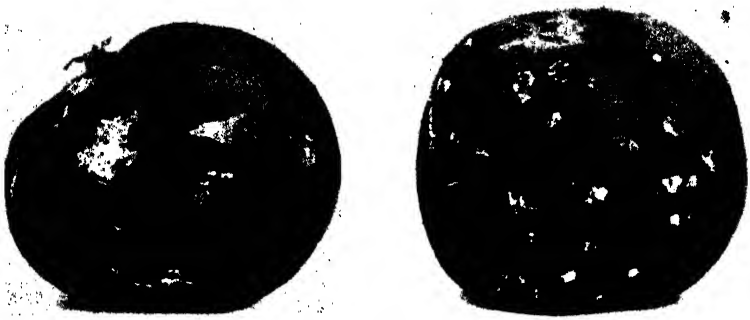
Pupa approximately x 12.

In the field eggs were chiefly found on mountain ash berries, only on two occasions in 1933 were they found on apples. They were deposited singly on the berries usually near the eye, sometimes among the dead stamens but more rarely near the stalk. On apples several eggs per fruit were placed but probably never in such large numbers as were found in the laboratory. In no case were eggs found on leaves or twigs.

Just before the eggs hatch they increase in size and the young larvae can clearly be seen inside.

*Habits of the Larvae.* Laboratory observations show that immediately after hatching the larvae examine the surface of the fruit and within a few hours bore out of sight into the interior.

Once within the fruit the larvae feed for a few days in shallow pits beneath the points of entrance and then proceed to eat out a maze of galleries which penetrate the flesh in all directions. Sometimes a larva reaches the core where the pips are then attacked, but larvae apparently never leave the fruit and re-enter it at another point.



Apples attacked by larvae of *A. conjugella*, showing points of entrance.

The larvae become fully fed in about six weeks, some, however, taking a much longer period.

Some mortality regularly occurred among the newly hatched larvae in the laboratory but the rate was very low. Where mortality occurred the larvae usually died outside the fruit having been unable to effect a proper entrance but sometimes a larva died in the shallow pit beneath the point in the skin through which it had entered.

*Pupation.* Observations on pupation were made in the late summer and autumn of 1932, the study being made in the laboratory. For the purpose infested mountain ash berries and apple were placed on soil in glass tanks. The larvae, when ready to pupate, left the fruit and wandered about until suitable positions for spinning cocoons were found. They usually descended to a depth of an inch or two into the soil and spun the cocoon there, but this occasionally took place among the dead leaves and stones on the surface of the soil. Cocoons have not been found in the fruit itself during this investigation ; however, it has been definitely recorded that cocoons do occur within the fruits (MacDougall, 1926, Ahlberg, 1927).

A period of twenty-four hours is occupied by the larvae in spinning the cocoon, and within two or three days pupation takes place. Pupation in the laboratory commenced in the middle of August but some larvae were still to be found in apples up to the middle of October.

Pupae could not be found in the field but according to other observers cocoons are spun in crevices in the bark of the trees as well as in the soil (Fryer, 1926). Those larvae pupating in the soil descended by means of threads or by falling with the fruits.

### Description of Attack on Apples.

The attack of the Apple Fruit Miner commences later in the season than that of the common apple-mining pests and when spraying against the latter is over. Consequently the presence of the Fruit Miner in the crop is not noticed and distinguished as such until the fruit is gathered.

The damage caused by the Fruit Miner, although difficult to detect on a young apple, is very characteristic on a mature fruit. The surface of an attacked apple bears several sunken discoloured patches in the centres of which are white glistening lumps of crystallized juice. The punctured epidermis immediately above the shallow pits made by the larvae just after they first enter the fruit becomes discoloured and sinks

Interior of apple attacked by larvae of *A. conjugella*, showing tunnels and subsequent rotting.

in. It is through these entrance holes that the apple juice exudes and crystallizes. When an apple presenting such an appearance is split open the flesh is seen to be mined by a maze of tunnels running in all directions. This is usually the work of several larvae and is quite distinct from damage caused by the larvae of the Codling Moth and Apple Sawfly.

### The Relation of Mountain Ash to the Attack of the Fruit Miner on Apples.

The distribution of the Apple Fruit Miner is closely allied to that of mountain ash, which appears to be its normal host. It has not been definitely proved, however, that the mountain ash is essential to the moth for the completion of its life-cycle, which might well proceed on apple alone, although in all cases where attacks of the Fruit Miner have been recorded on apples, mountain ash trees have been present in the locality concerned. In Kent, in 1932, it was observed that apple trees most heavily infested were those nearest to woods containing mountain ash trees; the moth being a weak flyer does not apparently travel far.

In some districts where the moth has been found during several successive years on apples it was noted that attacks were biennial, the most severe damage occurring every other year. This fact has been linked up with the relative abundance of mountain ash berries in those years of negligible attack on apple, and the relative scarcity in years

of severe infestation on apple. It has therefore been suggested that the Fruit Miner only turns its attention to apples when there are insufficient mountain ash berries available for it, a preference for mountain ash being assumed (Ahlberg, 1927, MacDougall, 1926).

This state of affairs is evidently true in Kent for our own observations show that in 1932 a severe infestation occurred but in 1933 the attack was negligible as it also was in 1931, previous to which year no information could be obtained.

We have made an additional observation which may have some bearing on the occurrence of biennial attacks on apple. Some larvae which pupated in the laboratory in the autumn of 1932 failed to emerge as adults in 1933 but on examination the pupae were found to be still viable. It is thought that moths may emerge from these pupae in 1934, a state of diapause existing which causes some pupae to hibernate through two winters and also to pass through a summer in this stage. Assuming then, that the majority of pupae pass into this condition of diapause, from which they emerge after two years, the relative abundance of adults in alternate years would be explained, in which case apples would be probably attacked in the year of greater emergence. It is hoped that observations during the current year will give further information on this phenomenon.

PRELIMINARY ATTEMPTS AT CONTROL.

It may be of interest to mention two methods tried in the laboratory to see if the insect could be readily killed in the egg or larval stages.

Two batches of eggs were lightly dusted over with a Derris dust ten days after they were laid. The young larvae could be seen inside the eggs which were due to hatch in three or four days. About half the eggs hatched but the young larvae were killed on leaving the eggs or immediately afterwards, as soon as they touched the dust. The dust may have inhibited the hatching of some of the eggs but it must be remembered that mortality of ova was often observed to be high when large numbers were present on a single fruit.

The second method consisted of spraying two batches of eggs with an emulsion of cotton-seed oil and soap. In this case the majority of the eggs hatched and more than half of the larvae burrowed into the fruit ; others were trapped in the oil film still remaining on the fruit especially round the eye and stalk regions.

No other methods were tried owing to an insufficient supply of eggs being obtainable.

The above work was carried out in the Department of Entomology of the South-Eastern Agricultural College, Wye, Kent, under the supervision of Mr. S. G. Jary, to whom the writer's especial thanks are due for permitting it to be undertaken in the department and for assistance in it at all times.

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# TWO NEW HOPS: "BREWER'S FAVOURITE" AND "BREWER'S GOLD"

By Prof. E. S. SALMON.

THE work of breeding new varieties of hops, using as parents species and varieties obtained from different parts of the world, was initiated at Wye College in 1907. Since 1920 an annual grant towards the maintenance of the Nursery has been received from the Research Committee of the Institute of Brewing. Through this grant Mr. A. H. Burgess has been enabled to carry out the chemical work of analysing the seedlings raised with respect to their preservative (brewing) value.

Since 1917 invaluable assistance has been given by the Research Station, East Malling. Cuttings of the most promising new varieties have been sent from Wye and planted out at East Malling. A very large number of new varieties, and also of commercial varieties for purposes of comparison, have been picked, dried and weighed separately each year. The material and data obtained have given information as to cropping capacity and enabled chemical analyses to be made. It has also been possible to use part-pockets of the hops for tests in the brewery. The work of collecting these data, and superintending the Nursery work at East Malling, has been carried out by Mr. Jesse Amos and, since 1927, by Mr. F. H. Beard.

Recently, small plots of some of the most promising new varieties have been established at Wye, and these have afforded material for further brewing trials and for propagation.

An account of the trials at the Research Station, East Malling, is given in the Annual Reports which have been issued (1),* and a general account of the results of the breeding work at Wye College will be found in two papers published in the *Journal of the Institute of Brewing* (2), (3).

Among the new varieties which have been sufficiently tested by field trials, chemical analyses and brewing experiments for their commercial cultivation (under suitable conditions) to be recommended, are two which have been referred to, in the various reports issued, under Ref. Nos. OP21 and C9*a*. These will now be described fully.

REF. NO. OP21.—This hop was raised in 1912 from a seed collected from a seedling, Ref. No. K52, which originated in 1909 from a plant of the American variety "Oregon Cluster",† growing at Wye—the male parent being in both cases an English male hop. Thus the grandmother of OP21 is the American variety "Oregon Cluster".

* These numbers will be found in the List of References given at p. 104.

† This plant was kindly sent in 1928 by Messrs. Wigan, Richardson & Co., Hop Merchants, London, from their hop yards in Oregon, U.S.A., as a male plant, but proved to be the female American commercial variety "Oregon Cluster". This variety, which is unsuitable for cultivation in this country, as the crop does not mature under English weather conditions, is a form of the species *Humulus americanus*. Consequently OP21 represents a hybrid between this species and the European species, *H. lupulus*, from which all the English cultivated varieties, and all English male hops, have been derived.

*Botanical Characters.*—Bine green, tinged brown in longitudinal bands; cone large, up to 2 in. long, oblong or cylindric-oblong, somewhat flattened, often furrowed, at first of a cold green colour, but showing a yellowish tinge when fully ripe, tip rounded, loosely closed. Fertile laterals and cones are shown in Figs. 1, 2.

*General Characters.*—OP21 was planted out in the Hop Nursery at Wye in 1914, and attracted attention in 1919 by its fruitful bines, "hopping" low down, and by its rich cones, free from leaves in the cluster. The hops when dried have an attractive "silky" side. The same year it was sent to the Research Station, East Malling, for a commercial trial. OP21 is a heavy-cropping variety, as the following table, compiled from the records kept at East Malling, shows.

TABLE I.

| Year. | Estimated Yield per acre (889 hills to acre). cwt. |
|---|---|
| 1922 | 20¾ |
| 1923 | 21 |
| 1924 | 31¾ |
| 1925 | 25¼ |
| 1926 | 22¼ |
| 1927 | 13¾ |
| 1928 | 20½ |
| 1929 | 20 |
| 1930 | 22¼ |
| 1931 | 11½ |
| 1932 | 16½ |
| 1933 | 14 |

It will be seen that low yields were obtained in certain years. This was due to various vicissitudes. In 1927 the poor crop was due to the combined effect of wet weather and uncontrolled attacks of the Downy Mildew on the cones.* In 1931, the season was wet and it is possible that inadequate protection was given against Downy Mildew.† In 1932 a slight attack of Downy Mildew was reported on the cones.‡ In 1933 the crop was seriously reduced through the effects of a severe hailstorm in June. Mr. F. H. Beard gives the information, further, that the fall in yield of OP21 (omitting 1927) has occurred since a somewhat generous nitrogenous manuring was discontinued—the amounts of nitrogen per acre given in 1931 and 1932 being only 156 and 198 lb.

It can safely be stated that OP21 is as heavy a cropper as the Fuggle; it is naturally rather a weak grower and will respond to nitrogenous manuring; it should not be pulled too hard. There was an indication in 1933, on a farm in Kent, that this variety withstands drought better than the Fuggle. It is a late hop, coming after the Fuggle. It is both easy to pick and easy to dry.

As regards susceptibility to disease, OP21 is liable to attacks by Downy Mildew on its cones to about the same extent as are the ordinary commercial varieties. The three routine sprayings of home-made Bordeaux mixture, applied as advocated in the Wye College Leaflet (4), will secure a healthy crop in any season. As regards Downy

* See *Eleventh Report on the Trial of New Varieties of Hops*, 1927, p. 8 (1928).
† See *Fifteenth Report, etc.*, p. 15 (1931).
‡ See *Sixteenth Report, etc.*, p. 17 (1932).

Mildew attacks on the bine, OP21 has given no special trouble ; the hills at East Malling Research Station and at Wye are quite healthy, and the strap-cuts not affected.

OP21 has never been attacked by " mould " either at Wye or at East Malling.

Against " mosaic disease " OP21 is immune, since it is capable of carrying in its sap the virus which is the cause of this disease, without in any way being affected. It will constitute, therefore, a source of mosaic disease if planted contiguous to mosaic-susceptible varieties, such as the true Goldings (Canterbury Golding, Bramling) or the Golding varieties Tutsham or Cobb's, since the virus is liable to be transferred by insects or other unknown agencies from " carriers " such as OP21. Consequently it is safe to plant up OP21 *only in or adjoining gardens where the Fuggle alone is grown*, as this variety also is capable of carrying the virus of mosaic disease without being in any way affected.*

*Aroma.*—In most seasons a slight " Oregon " or " American " aroma can be detected in the cones of OP21. It appears to be sometimes absent—thus in a sample of the 1931 growth neither Mr. C. G. Tosswill nor the late Mr. A. Willmer (of the firm of Messrs. Wigan, Richardson & Co.) could detect any trace of American aroma, and their verdict on the sample was that it possessed a " good flavour "† ; while, on the other hand, on samples of the growths of 1932 and 1933 Mr. Tosswill reported " mild Oregon flavour " and " strong American flavour " respectively. On the whole, it would appear that OP21 possesses in most seasons a distinct but not marked Oregon aroma, derived from its American grandmother. To what extent, if any, this American aroma will be transmitted to the beer brewed, only brewing experiments can show.

*Preservative Value.*—Since 1926 the crop of OP21 grown at East Malling Research Station has been analysed each year by Mr. A. H. Burgess and his assistant. The soft resins—the most important constituents of a hop for brewing purposes—have been determined by the Ford and Tait method of analysis, in their component parts, the $\alpha$ acid and the $\beta$ fraction‡ ; these percentages, expressed according to the formula $\alpha + \frac{\beta}{3}$ have been found to give the best estimate of a hop's antiseptic, or preservative, power. Fig. 3 shows the preservative power of OP21 during the years 1926-33 ; also of the richest sample of the variety Fuggle grown at East Malling during these years under the same conditions of soil, climate and manuring. It will be seen that OP21 each season has been considerably " richer ", i.e. with a higher percentage of soft resins, than the variety Fuggle.

*Brewing Trials.*—Since 1925, part-pockets of OP21, grown at the Research Station, East Malling, have in certain seasons been used in brewing trials by various brewers.

In 1925 in tests made by Messrs. J. S. Ford and A. Tait (6) at the Brewery of Messrs. Wm. Younger & Co., Edinburgh, it was reported upon as " a fair average cellar hop, pleasant aroma, not very strong ", and, as giving when used as a dry hop, a " delicate pleasant " flavour to the beer.

In trials carried out by Messrs. Lones and Grant (7) at Messrs. Mitchells & Butler's Cape Hill Brewery, Birmingham, OP21 was compared with a good British Columbian hop. The following conclusions were reached :

(1) the high resin percentage of the New Variety OP21 is quite exceptional in English-grown hops ;

* The varieties Colgate and Tolhurst are likewise potential " carriers " of mosaic disease.

† See (1) *Fifteenth Report, etc.*, p. 13 (1932).

‡ These figures will be found in the Reports on Hop Trials (1) issued from the Research Station, East Malling.

(2) on the whole, it may be said that the tests showed OP21 to be possessed of a brewing value not a great deal below British Columbians so far as keeping properties are concerned, and quite equal to the latter in flavouring qualities. In fact the flavour of the New Variety would be more acceptable to many.

In 1926 trials were made by Mr. B. N. Thompson (8) at the Experimental Brewery, College of Technology, Manchester, in which OP21 and other new varieties were compared with a representative sample of Fuggle. The conclusion was arrived at that when used as a copper hop OP21 produced beers of good flavour and good keeping properties.

In 1930 Messrs. W. T. Smith and A. J. C. Cosbie (9) published the results of brewing trials carried out in the Brewery of Messrs. Truman, Hanbury, Buxton & Co., London. OP21 was considered to possess a " distinct Oregon flavour " ; and to show " promise of utility as a copper hop in suitable blends ", but with too harsh a flavour for use as dry hops.

In further experiments by Messrs. Smith and Cosbie (10), OP21 was reported upon in physical examination as " a very stout good hop. Distinct Oregon aroma, good rub. First-class copper hop (Oregon)." The results of the brewing trials showed that " a rank clinging bitter was produced, suggestive of its Oregon parentage. For the same reason it was unsuitable for dry hopping beers." The note is added : " Under the conditions existing at this brewery the flavour typical of Oregon hops is liable to be rather pronounced."

In Laboratory brews carried out by Mr. F. E. Day (11) with OP21 and other varieties of American parentage, the following conclusions were reached. In the " Summary of all brews " (p. 204), OP21 was reported upon as " A very good hop. Of medium bitterness and good character. Almost as good as Goldings " and, under " Conclusions " (p. 205), " The hops of Oregon × English parentage tend to have harder bitter flavours than high-class East Kent Goldings, but this flavour was not so pronounced as in the case of the Oregon hops. It was scarcely detectable in OP21, which could be classed as a first-class copper hop."

In 1932 Mr. J. S. Ford (13) carried out further brewing trials at Messrs. Wm. Younger & Co.'s Brewery, Edinburgh, using OP21 and certain other new varieties of American parentage. The varieties OQ17, OP21 and M45 were used to replace Californian hops. The beers were tasted by eight brewers. The conclusions arrived at were as follows : The unanimous decision was that the hops as regards resulting flavour were perfectly satisfactory as copper hops. Another large scale trial was carried out to test the value of the hops as " Dry Hoppers". The unanimous opinion of the same testers was that OP21, M45, OQ17 and Y86 were quite excellent dry hops as regards flavour and form.

*General Conclusions.*—The information given above justifies the conclusion that OP21 has a commercial future. It is a heavy-cropping variety, is consistently " richer " than the Fuggle variety, and has proved satisfactory in brewing trials carried out in various breweries. Its particular soil requirements have yet to be determined. A half-acre plot is being grown at East Malling Research Station, on light loamy soil ; and " demonstration plots ", planted up with sets raised at East Malling, have been established on two farms—one, of three-quarters of an acre, at Cranbrook, Kent (Mr. G. Calcutt), on light loamy soil, and the other, of half an acre, near Hereford (Captain C. R. Edwards, Preston Wynne), on heavy clay loam or marl. OP21 is also being grown in Kent on a farm near Tonbridge, on shallow light loam, and also on a stiffer soil.

It is proposed to give OP21 the name of " Brewer's Favourite ". Applications for sets should be made to the Director, Research Station, East Malling, or to Wye College.

REF. NO. C9*a*.—This hop was raised in 1919 from a seed collected from a plant (Ref. No. BB1) in the Hop Nursery at Wye College, the male parent being an English male hop. The plant Ref. No. BB1 was sent in 1916 by Prof. W. T. Macoun, Dominion Horticulturist for Canada, as a cutting from a wild hop growing at Morden, Manitoba,*

* Professor Macoun wrote in December 1916 : " The Town of Morden is situated in Southern Manitoba near a range of hills. The wild hop grows along a creek which flows through the town of Morden. Old residents in this town assure me that there has never been any introduction of cultivated hops in this district. The wild variety, growing so abundantly along the creek, was transplanted on the town lots, especially along the fences, and back lanes, to cover unsightly places." It would appear, therefore, that this plant, the female parent of C9*a*, is the species ***Humulus americanus***.

and was planted out in the Wye Hop Nursery in 1917.* The seedling C9*a* was planted out in the Nursery in 1922, and attracted attention in 1925 by the extraordinary richness of its cones, which were so full of " condition " that on being opened and rubbed they became greasy or " buttery " to the touch. It was propagated and cuttings were sent in 1926 to the Research Station, East Malling, where a row of 15 hills became established by 1929. More recently, a plot of 154 hills has been established at Wye, and the crop from this, as well as that from the hills at East Malling, have been used in a number of brewing trials.

*General Characters.*†—An idea of the general appearance of the cones can be gathered from the illustrations given in Figs. 4, 5. The cones are of a medium size, the larger ones pointed at the tip ; there is a tendency for small " under hops " to be produced, somewhat hidden among the leaves, so that clean picking may be rendered difficult. Ample compensation, however, is found in the unrivalled richness of the cone, which is noticeable to the eye, even in the smaller cones of the lowest branches. It is late in season, and can safely be left to be the last picked, as the cones " hang " well.

C9*a* is about as susceptible to Downy Mildew as the commercial varieties at present grown in this country. As mentioned below, it is a very heavy cropper, producing dense " heads " of hops. Since C9*a* is a late variety, three thorough sprayings of Bordeaux mixture are essential in wet seasons for the production of a healthy crop ; it is a good plan to apply the second spray when the hops are in full burr, and the third as soon as the burr has fallen ; in these later sprayings the use of the machine known as the " Bordeaux Blower " facilitates the passage of the spray through the dense " heads ".

No attacks of " mould " have occurred either at Wye or at East Malling.

C9*a* is immune from mosaic disease, being a " carrier ", like OP21 (see above).

C9*a* is a very heavy cropping variety, as the following table, compiled from the records kept at East Malling, shows.

TABLE II.

| Year. | Estimated Yield per acre (889 hills to acre). cwt. |
|---|---|
| 1929 .. .. .. .. .. .. | 24¾ |
| 1930 .. .. .. .. .. .. | 28 |
| 1931 .. .. .. .. .. .. | 21¾ |
| 1932 .. .. .. .. .. .. | 27 |
| 1933 .. .. .. .. .. .. | 23¾ |

It will be seen that over the past five years C9*a* has cropped at the average rate of 25 cwt. to the acre.

*Aroma.*—This is of the American type, derived doubtless from the American female parent. Mr. C. Gibson Tosswill has detected in it a difference from the usual

* BB1 was early in season at Wye in 1918, flowering on 10 July, and forming large, coarse, somewhat pointed cones, with a tendency to produce leafy outgrowths in the cones. The plant died during the Winter of 1918-19. Two cuttings of BB1 were planted out in the Wye Nursery in 1918, and both died in 1919, one through the attack of mosaic disease and the other from an unknown cause.

† The botanical characters of C9*a* will be given in this *Journal* next year.

American aroma, and has characterized it on several occasions as a distinctive " Manitoba " aroma. Thus on a sample of the 1932 growth, Mr. Tosswill reported,* " Pungent ' Manitoba ' flavour."

*Preservative Value.*—Since 1928 the crop of C9*a* grown at East Malling Research Station has been analysed for its preservative value on the lines mentioned above, under OP21. Fig. 6 shows (at top) the preservative value of C9*a* during the years 1928-33. In the same Fig. is shown also the preservative value of two classes of hops during the same period. The line at the bottom gives this value for the richest English commercial varieties, as grown at East Malling under the same conditions as C9*a*. In some seasons the Goldings have been the richest, in others the Fuggle. The middle line indicates the value of the richest sample, obtainable on the market, of American hops grown in America.† It will be seen that in the years 1928 to 1930, and in 1932 and 1933, C9*a* was superior in preservative value to the richest American hops.‡ Thus in five out of the six years in which C9*a* has been grown at East Malling, it has exceeded in preservative value the richest American hops, which in this respect are the most powerful of any variety cultivated in any country (see (2), p. 71). In 1932 and 1933 it became clear that C9*a* had the distinction of being the richest hop in the world.

*Brewing Trials.*

In 1931 Mr. F. E. Day (11) carried out some laboratory brews with C9*a* and reported that, in the proportion used, it gave an extremely rank and unpleasant bitterness.

In 1931, also, Mr. G. T. Cook, at Messrs. Fremlins' Brewery, Maidstone, carried out dry hopping tests in the cask with C9*a* and other seedling varieties of the same parentage and reported (12): " It was found that the rank flavour of the hops did not come through to such a marked extent as had been anticipated from the results of physical examination of the hops. The flavours were comparable with that of beer dry hopped with a strong Oregon hop. C9*a* was considered to be the best of the four varieties tested."

In 1933 dry hopping tests were made in a Kent Brewery, and the Head Brewer, Mr. C. W. Rudgard has described these, and the results obtained, as follows (14). For purposes of comparison a blend of Oregon and Saaz hops at the same rate per barrel was used. " On comparing the finished ales it was found that in all ways the ' C9*a* ' ale was equal to the ' Oregon-Saaz ' ale, and when considering the two ales from the aroma and hop flavour standpoint, there was a delicacy of bouquet in the ' C9*a* ' ale which justified the view that the C9*a* hops could replace an Oregon-Saaz blend with advantage. It is worthy of note that only by using an Oregon-Saaz blend could a really good aroma and flavour be imparted to the type of ale in question, and the C9*a* has proved quite as good and even a little better. Similar tests conducted with a bottling ale confirmed the previous results. Further similar experiments, using choice East Kent hops for the comparison, showed that here the difference in the aroma of the finished beers was very marked and the C9*a* hop was easily the better when used in the manner indicated. Tests in cask beers did not bring out the flavour of the C9*a* hops quite as much as might have been expected, but they seemed quite equal to very choice English hops in imparting a pleasing hop flavour to the cask beers. The results suggest that if C9*a* could be grown commercially as grown at Wye and at East Malling, foreign hops, especially American hops, could be dispensed with by those brewers who are in the habit of using a percentage. These C9*a* hops gave all the flavour of the American hop without any unpleasantness and, so far as could be judged, the keeping value of the beer left nothing to be desired."

In 1933 and 1934 Mr. J. S. Ford used C9*a*, together with certain other new varieties, in brewing trials at Messrs. Wm. Younger & Co.'s Brewery, Edinburgh, Scotland. In the Report (15) on the 1933 results, it is stated that the amounts used were in ratio to the preservative value of the hop,

* *Sixteenth Report*, etc. (1), p. 15.

† Kindly supplied by Messrs. Wigan, Richardson & Co., Hop Merchants, London.

‡ The actual amounts of the increase of preservative value of C9*a* over the samples of American hops were as follows: 1928, 1·21 per cent; 1929, 0·83 per cent; 1930, 1·47 per cent; 1932, 3·11 per cent; 1933, 2·76 per cent. (See *Report on the Trial of New Varieties* (1).)

the Fuggle being taken as the standard. Used as a copper hop in small scale brewings, C9*a* was found to be unsuitable for pale ale production. Tested as a dry hop in the barrel, C9*a* was stated to be "strong in flavour but not very unpleasant". The general conclusion was reached that "C9*a* used in smaller amounts or used in a blend might prove satisfactory for certain districts. This hop has the highest antiseptic value of the lot and though, consequently, used in smaller quantities in the copper test, was still condemned for its unpleasant flavour. Notwithstanding this, as it is the mildest of the Manitoba varieties and has the highest antiseptic value,* its further cultivation seems desirable."

In the Report on the 1934 trials, it is stated (16) that "the general opinion was that the hop C9*a* has too pronounced an aromatic flavour for use in pale ales either as dry or copper hops. The remarkably high preservative value of C9*a* is again evident this season and it is extremely unfortunate that its flavour, even with a very low hopping rate, still remains unsuitable for pale ales."

Trials with C9*a* and another new variety, X35, have been carried out at the Brewery of Messrs. W. H. Brakspear & Sons, Ltd., Henley-on-Thames, and Mr. J. E. Chalcraft, Head Brewer, has reported on these as follows: "As the weights of each variety we had were quite small, the majority of the tests carried out had to be done in the form of dry hopping experiments in cask, there not being sufficient of them available for more than two copper experiments with each variety. In comparing each of these two new varieties with a good Worcester Fuggle, the results indicate that both the new varieties are suitable for use up to 20 per cent in all beers, and that the C9*a* possesses better preservative qualities than the X35, which again was better than the Worcester Fuggle; also, so far as my own personal opinion is concerned, I prefer the flavour of the C9*a* to the X35. In the copper I found that I was able to use up to 20 per cent of C9*a*, even in pale ales, without any deterioration of flavour, the same being possible with the X35. I did not make any experiment with stout, as both these hops would undoubtedly be very suitable for this purpose, and I thought that probably the results obtained with mild and pale ales would be more interesting. In conclusion, the results might be summed up by saying that I think the C9*a* will be most valuable for blending to a moderate extent in beers, and to a much greater extent in stouts." (5) (Abridged report.) In a further communication, Mr. Chalcraft wrote: "I think that I should be fairly safe in saying that it would undoubtedly be possible to use a larger percentage of C9*a* than Americans without getting any unpleasant hop flavour."

*General Conclusions.*—C9*a* is a hop of exceptionally high preservative power, but its strong aroma of the American type is so different from that of any variety cultivated in this country that it would be inadvisable for any grower to plant up with it unless he is assured of being able to place the crop with a brewer who desires this type of hop. As has been stated, C9*a* provides a substitute, of equal or greater value, for American hops for those brewers who would prefer an English grown hop, but the extent of such a market remains to be seen.

C9*a* has been found to be eminently suitable for stouts; further brewing experiments are required to determine how far it has an extended use. It has been planted up (with other new varieties) on the Hop Farm of Messrs. Guinness, at Bodiam, Sussex, and has given such good results that the acreage is being extended. A second firm of brewers has applied for sets for planting up this year. C9*a* is being grown on a small scale by a few farmers in Kent, Sussex and Hampshire. For the reasons given above (p. 96), *C9a, being a "carrier" of mosaic disease, is safe to grow only where the Fuggle variety alone is cultivated.*

It is proposed to give C9*a* the name of "Brewer's Gold". Applications for sets should be made to Wye College, or to the Director, Research Station, East Malling.

I am indebted to Mr. W. M. Ware for taking the photographs reproduced in Figs. 1, 2, 4, 5.

* In reply to an enquiry, Mr. Ford has written: "As regards your query *re* C9*a*, I have never come across, in my experience of preservative value dating back twenty-two years, any commercial hop equalling it in antiseptic value."

FIG. 1.
Branch of Hops of *Ref. No.* OP21 ("Brewer's Favourite"), ⅓ nat. size.
Wye, Sept. 1931.

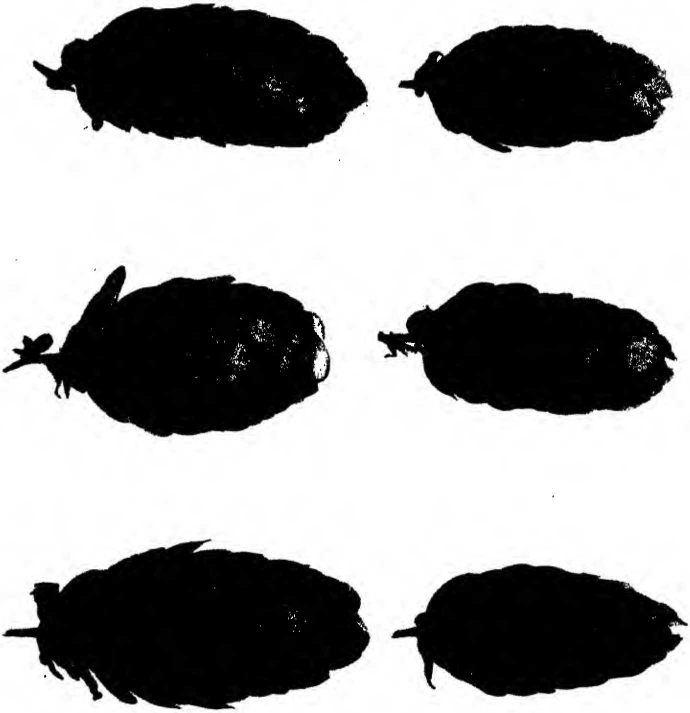


FIG. 2.
Six Cones of *Ref. No.* OP21 ("Brewer's Favourite"), nat. size. Wye, Sept. 1931.

FIG. 3

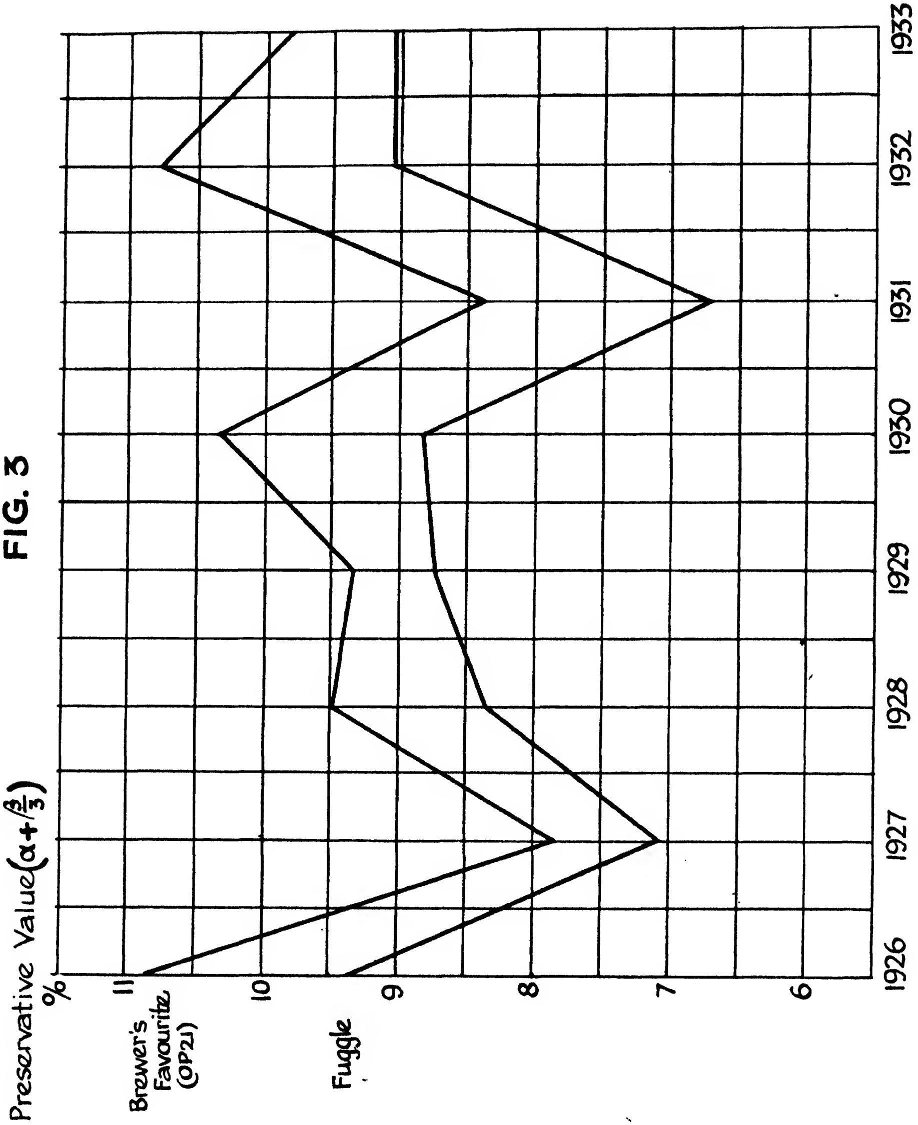

Preservative Value $(\alpha + \frac{\beta}{3})$
%
11
10
9
8
7
6
Brewer's Favourite (OP21)
Fuggle
1926
1927
1928
1929
1930
1931
1932
1933

Fig. 4.
Branch of Hops of *Ref. No.* C9*a* ("Brewer's Gold"), $\frac{1}{2}$ nat. size. Wye, 16 Sept. 1932.

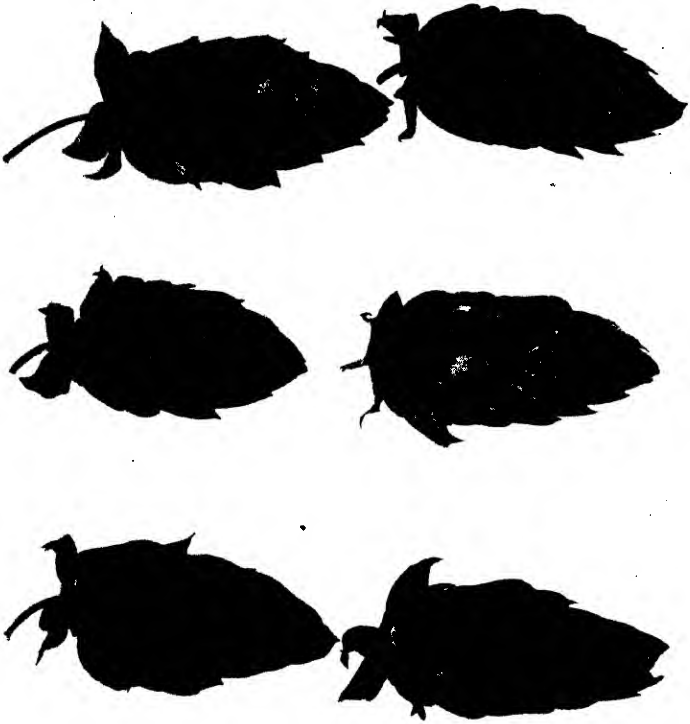
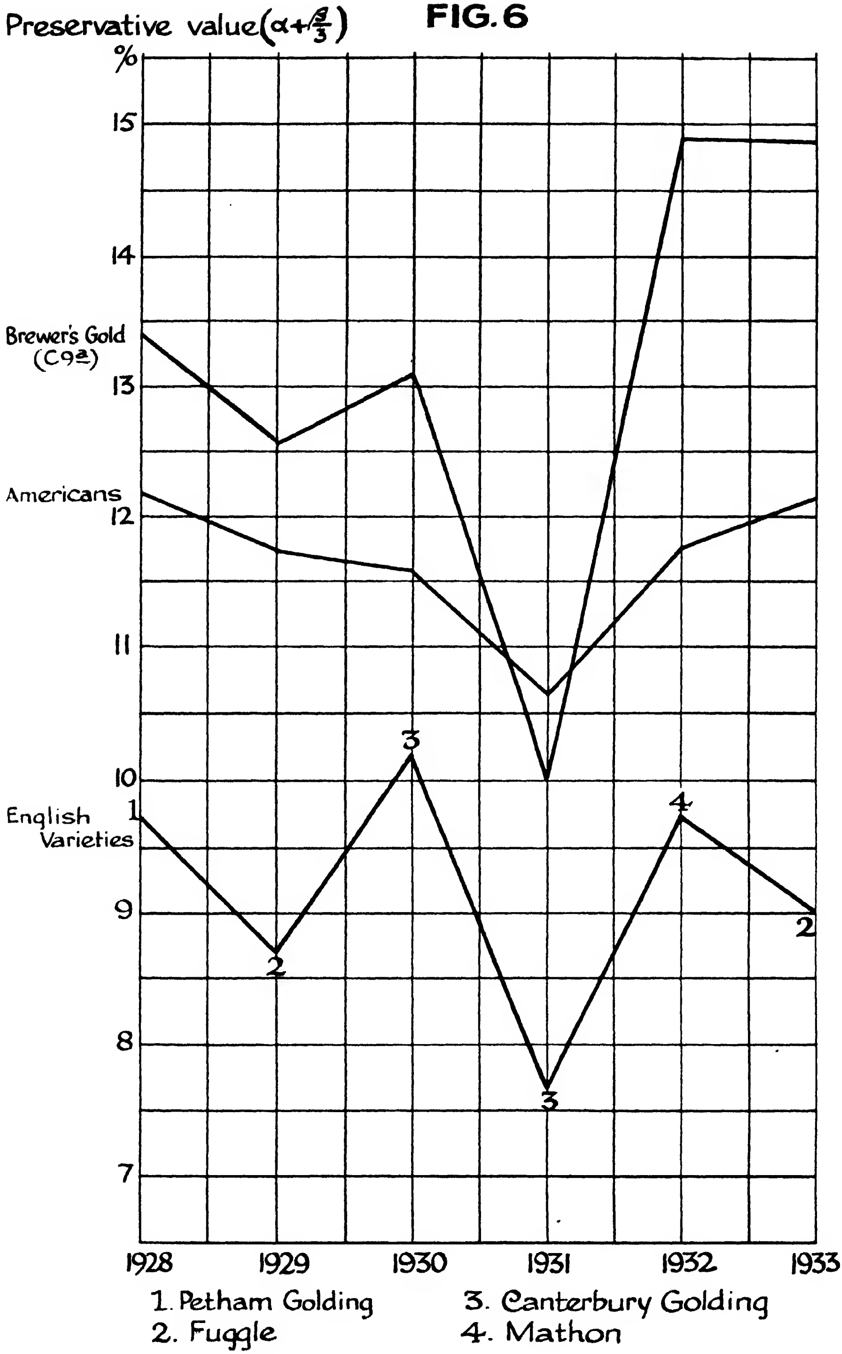


FIG. 5.
Six Cones of *Ref. No.* C9*a* ("Brewer's Gold"), nat. size. Wye, 16 Sept. 1932.

FIG. 6


Preservative value($\alpha+\frac{\beta}{3}$)
%
15
14
Brewer's Gold (C9a)
13
Americans
12
11
10
English Varieties
9
8
7
1928
1929
1930
1931
1932
1933
1
2
3
3
4
2
1. Petham Golding
2. Fuggle
3. Canterbury Golding
4. Mathon

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(1) SALMON, E. S. "Report on the Trial of New Varieties of Hops"; Nos. 1-16 (1918-33). East Malling Research Station, Kent.

(2) *Idem.* "The Value of Hop-breeding Experiments." *Journ. Inst. Brewing*, XXIII, 60 (1917).

(3) *Idem.* "Hop-breeding Experiments, 1917-30." (*Ibid.*, XXXVI, 578 (1930).)

(4) *Idem* and WARE, W. M. "The Hop Downy Mildew and its Control." 15 pp., 11 figs. S. E. Agric. Coll., Wye, Kent., Feb. 1931. Addenda, Dec. 1931.

(5) *Idem.* "Report on Hop Investigations at Wye College, 1932-3." *Journ. Inst. Brewing*, XL, 185 (1934).

(6) FORD, J. S. and TAIT, A. "Evaluation of Varieties of Hops by Chemical, Biological and Dry Hopping Tests." *Ibid.*, XXXII, 19 (1926).

(7) LONES, J. M. and GRANT, T. E. "Report on the Results of Experimental Brewings with Certain New Varieties of Hops received from the Research Department of the Institute of Brewing." *Ibid.*, XXXIII, 6 (1927).

(8) THOMPSON, B. N. "Experimental Brews with New Varieties of Hops Selected from those grown at the East Malling Research Station, Kent." *Ibid.*, XXXIII, 564 (1927).

(9) SMITH, W. T. and COSBIE, A. J. C. "Comparative Brewing Trials with Certain New and Commercial Varieties of Hops." *Ibid.*, XXXVI, 91 (1930).

(10) *Eidem.* "Trials of OP21 and OV7 at the Experimental Brewery of Truman, Hanbury, Buxton & Co., Ltd., London." *Ibid.*, XXXVII, 199 (1931).

(11) DAY, F. E. "Laboratory Brews with the New Hops." *Ibid.*, XXXVII, 202 (1931).

(12) COOK, G. T. "Trial of Manitoba Seedlings by Fremlins, Ltd., Maidstone." *Ibid.*, XXXVII, 202 (1931).

(13) FORD, J. S. "Practical Trials with East Malling Research Station Experimental Hops: 1931." *Ibid.*, XXXIX, 28 (1933).

(14) RUDGARD, C. W. "Dry Hopping Trials with C9*a* grown at Wye College and at the Research Station, East Malling." *Ibid.*, XXXIX, 28 (1933).

(15) FORD, J. S. "Brewing Trials with Hops from Wye College, Kent, 1932." *Ibid.*, XXXIX, 516 (1933).

(16) *Idem.* "Brewing Trials with Hops from Wye and East Malling, 1933 Crop." *Ibid.*, XL, 241 (1934).

# THE DOWNY MILDEW OF THE HOP IN 1933

By Prof. E. S. Salmon and W. M. Ware, M.Sc.

In 1927 and 1930, the years in which the attacks of Hop Downy Mildew were most severe, as we have recorded,* the rainfall at Wye for the growing season was, respectively, 17·57 inches and 17·02 inches; in 1933, notable for the hot, dry Summer, the rainfall was only 12·95 inches.

It is interesting to observe what progress the disease was able to make under the latter conditions. A consecutive account may best be gathered from the statements of growers themselves, and in the present article many of these have been included.

## Seasonal Course of the Disease.

The first "basal spike" (in a non-sporing condition) was observed on 27 March, on a hill of Canterbury Goldings in Wye Field hop garden. The hills in this garden were not yet "cut"; it is possible that in some cases the postponement of "cutting" ("dressing") the hill until late may be of advantage in the control of Downy Mildew, as the removal of all basal spikes and any infected buds on the uppermost part of the "crown" would be secured at the start of the new season's growth.

Mr. L. V. Blake kindly sent us, on 31 March, the following observations made on Messrs. Whitbread's Hop Farm at Beltring, Paddock Wood, Kent :—

"Basal spikes are to be found on uncut hills of Canterbury Golding and on other uncut Late varieties. At present our Canterbury Goldings are not very forward and it is only possible to recognize definitely spikes on forward hills. This morning, for the sake of information, I closely inspected a plot of 400 hills of Canterbury Goldings, and found 15 hills bearing typical spikes; 4 of these hills bore from 4 to 5 spikes each, and 11 hills, 1, 2 or 3 spikes."

On 3 April the first basal spike bearing spores was found at Wye, and on 5 April the Nursery Gardens (of six acres) were examined, and 291 basal spikes were collected. On 7 April a hop grower reported that he had found a few basal spikes in his Fuggle hop garden at Yalding. On 11 and 12 April the Wye Hop Nursery garden was again gone over, and more than four times as many basal spikes (of which 100 or so were "black with spores") were found as on 5 April.

A correspondent from Hereford reported that "there is a very considerable infection in all the Golding yards which I have seen, but so far I have not seen typical spikes on Fuggles this year." Some hop shoots sent in by this grower, from a Fuggle

* Salmon, E. S. and Ware, W. M.: "The Downy Mildew of the Hop in 1927." *Jour. Min. Agric.*, 34, No. 12, 1093-9. March 1928.
Salmon, E. S. and Ware, W. M. "The Downy Mildew of the Hop in 1930." *Jour. Inst. Brewing*, 37 (28 N.S.), No. 1, 24-31. Jan. 1931.

garden, which somewhat resembled basal spikes and were suspected of being such (" 3 out of 4 stocks have these ' spikes ' ") were found on microscopical examination to be uninfected—the temporarily arrested growth was probably due to the action of cold winds or of the fertilizer used.

On 8 May the first infection of the leaves of normal bine was noted in the Nursery Garden at Wye ; both the so-called " oil-spot " stage and brown, angular spots were present.

By 10 May " terminal spikes " were appearing in several gardens in Kent. The first two weeks of this month were showery and the weather was suitable for the production of spores and the spread of the disease. One grower from near Chartham, Kent, wrote on 10 May :—" In my garden (where the bine is early) I am meeting with numerous terminal spikes and am much troubled about the situation. These terminal spikes are just below the breast-wire. The basal spikes have not been very numerous, but are now coming on in quantity—they had been removed about once a week. I had contemplated wet spraying, but have decided to continue spiking." On 28 May a correspondent wrote from Ash, near Canterbury :—" Terminal spikes are beginning to develop in my Cobbs, now that they are trained to the string." On 19 May a correspondent from Ledbury, Herefordshire, sent examples of the upper part of the bine (4-6 ft. high), which was suspected of being diseased ; these were found to be terminal spikes—the terminal buds were pale and conidiophores with spores were present on the stipules which had been turned brown. On 23 May a grower from Bentley, Hampshire, wrote :—" Hundreds of terminal spikes are present in my hop gardens ; they have all appeared since last Tuesday." The grower stated that basal spiking had been carried out weekly, and that spores were present on the lower leaves of the trained bine. Similar communications were received from growers at Goudhurst and Horsmonden, Kent.

Since the quite erroneous idea is commonly held that the bine of the Fuggle variety is immune from Downy Mildew, the following communication, received on 28 May, from a grower near Yalding, Kent, seems worthy of record :—" I have now 15 acres of Fuggles. I dressed early and started tying up on 27 April. I found then very little Downy Mildew, the spikes arising mostly from runners. All basal spikes were pulled and carried off three times. About a fortnight ago the bottoms of the hills were cleaned out and the bines stripped of the three bottom pairs of leaves. The bine to-day is about half-way up the strings, 8-9 ft. high, and I have found very few terminal spikes so far, but the new growth at the bottoms has, especially in the old plant (five acres) come very badly with Downy Mildew ; the basal spikes, which may be as many as twenty-five in one hill, are pale yellow and very short, only about an inch tall, and their leaves are already black with spores. Further, where I pulled off the lower leaves of the bines, in many cases Downy Mildew shoots [' lateral spikes '] are appearing at the joint. I have not noticed any sporing patches on the leaves, except right at the bottom of the bine, where they distinctly have it—which is why I pulled them off. I have noticed that in one garden at Tovil 75 per cent of the heads are infected."

While, on the whole, growers reported a lessened number of both basal and terminal spikes in comparison with those found in the 1932 season, their number was still considerable in many cases. Mr. A. H. Burgess has reported (this *Journal*, No. 33, p. 31 (1934)) the following facts relative to the appearance of " spikes " in the Wye Field

hop garden consisting approximately of 2 acres each of Early Birds, Cobbs and Canterbury Goldings.* The figures refer almost entirely to basal spikes, as there were comparatively few terminal and lateral ones; the numbers given in brackets are those observed in 1932:—Early Birds, 3,097 [4,750]; Cobbs, 1,530 [4,716]; Canterbury Goldings, 8,371 [19,280].

On a farm near Wye, basal spikes had been very numerous in the earlier part of the season, and from the start "spiking" had been done by two women twice a week. Owing to these precautions, the gardens were found, on a visit paid on 12 June, to be free from terminal and lateral spikes,† and no "angular spots" with spores were to be seen on the leaves. The bine in the Eastwell Golding garden was about three-quarters up, and in the Bramling garden, near the top. Both gardens had been sprayed with half-strength Bordeaux mixture when just above the breast-wire (4 ft. 6 in.); a noticeable amount of injury had been caused to the upper leaves in the form of "pin-hole" and marginal scorch, the latter causing many leaves to crumple (with down-curled margins); the bine, however, grew away later and no serious check was caused.‡

In gardens where terminal spikes were present, it was noticeable that the effect of the hot, dry weather in early June tended to cause them to dry up and remain in a non-sporing condition. A correspondent from Tenbury, Worcestershire, wrote on 16 June:—"Downy Mildew shows more on the leaf in the Midlands than it has ever done before, but the hot weather keeps it under until Bordeaux spraying can be done."

At the end of June, the bine was well up; the soil was dry and, generally speaking, there was little or no sign of Downy Mildew. The routine spraying with home-made Bordeaux could be carried out with every prospect of obtaining a disease-free crop. Where this was done, on bine over the top wire, no appreciable injury in the form of scorching occurred.§ The majority of growers wisely adhered to the practice of giving the three sprayings (the first when the bine is at the top, the second immediately before the burr appears, or when it has just appeared, and the third immediately the burr has disappeared) which experience has shown will protect the crop in the wettest seasons; many growers, however, gambled on the continuance of the hot, dry weather, and omitted the first, or second, spraying. Some three-quarters of the hop acreage was well sprayed with Bordeaux mixture. The following communication (26 July) from a grower at Tenbury Wells, Worcestershire, is typical, as regards the spraying programme, of many received:—"Although the Downy Mildew has not been much in evidence since the bine reached the top there was the most severe attack I have yet

* This garden was sprayed six times, from 10 May to 7 August, with half, three-quarters or full-strength home-made Bordeaux mixture. A heavy crop, averaging 25·75 cwt. per acre, over the three varieties, was picked, and no Downy Mildew was present on the cones. The top price for grade in each variety was secured.

† The occurrence of these had been "almost negligible".

‡ In these gardens many cases occurred where the tops of the main bines were yellowish (with abnormally large stipules), stiff and inclined to leave the string. The grower feared the possibility of an outbreak of the "mosaic disease"; from other gardens, in the parishes of Eynesford, Wickhambreaux, Paddock Wood, East Peckham, Goudhurst and Canterbury (on the varieties Canterbury and Eastwell Goldings, Bramling and Fuggle) similar specimens were sent in by growers who suspected these would develop into "terminal spikes". We were able to satisfy the growers in all cases that no disease was present, and that the condition was probably due to abnormal weather conditions (possibly sudden changes of temperature).

§ Severe scorching was recorded in one case, where the spraying was done (before 10 o'clock and after 3 o'clock) on a day "when the sun was exceptionally fierce"; the bine recovered fully.

experienced in the early stages. I am proposing to complete the three sprayings as usual."

It was commonly assumed during July and August that the Downy Mildew had been completely suppressed by the hot, dry weather. This, however, was far from being the truth, as is shown by the facts detailed below, and it is clear that had rain come in August, there was sufficient infective material to have imperilled the health of the crop in unsprayed gardens.

On 17 July in the College Nursery Garden, a few tips of fertile laterals were found to be spiked and angular spots were present on the leaves of laterals just above the breast-wire. In the same garden, on 19 July, Downy Mildew in a sporing stage was observed on the immature cones of an early Seedling Variety (Ref. No. V61). An inspection of Wye Field Garden was made on 25 July, each alley being looked over; all the varieties (Early Bird, Cobbs and Canterbury Goldings) were in burr; Downy Mildew was almost completely suppressed, only two lateral spikes being found and no angular spots on the leaves—the garden had already been sprayed with Bordeaux mixture seven times by this date. Similarly, in a hop garden (of Canterbury Goldings) near Sittingbourne, Kent, the examples of short, lateral spikes sent in on 26 July by the grower were found to be old and dried up. This grower, taking no risks, was having all the infected laterals cut off, in case the mildew became resuscitated by rainy weather, when its spores might irretrievably damage the adjacent burr.

Although this was realized by few hop growers, the Downy Mildew was present, in a sporing condition, on the bine during August. On 3 August it was brought to our notice by Mr. A. H. Burgess in the Canterbury Goldings in Wye Field hop garden; here it occurred as minute black spots (with spores) on leaves of lateral branches high up on the top wire, among the thick "heads" of the bine. Mr. Burgess reported that he had noticed Downy Mildew, on 3 August, on leaves in the "heads", in a garden of Bramlings, near Wye. On 4 August the fungus was found sporing profusely on the lower leaves of hop seedlings in the Wye Nursery Garden. On 10 August a grower from near Canterbury brought in a "head" of hops from his Bramling garden, showing a slight attack of Downy Mildew on the young cones. The plant in question was a "rogue"; only two cones were attacked, and no "angular spots" were present on the leaves. On 8 August Mr. F. H. Beard, of the Research Station, East Malling, wrote:—"Downy Mildew has been rather troublesome lately owing to two factors: (1) the heavy downpour about a fortnight ago followed by very hot steamy days and thick, morning mists; (2) hail damage, causing a very late crop of laterals (particularly low down) arising after the Bordeaux spraying on 17 July, which were not protected with Bordeaux until the post-burr spray was given." On 18 August one hill in the Wye Nursery Garden showed cones with the "petals" blackened with the conidiophores and spores of Downy Mildew, and the leaves of the laterals showing angular spots, with spores. On 19 August a grower from Ledbury, Herefordshire, sent a lateral branch of Bramlings, showing one cone only badly attacked by Downy Mildew. On 18 August it was observed that a "wild" hop, growing in the ditch alongside a Fuggle garden, bore the Downy Mildew, in a sporing condition, as small black spots on the lower surface of the younger leaves.

The above examples are quoted in order to show that the disease was in an active condition as late as August. Thanks, however, to the hot, dry weather of the latter part of that month and during September, the Downy Mildew made no spread from any isolated source of infection, and was practically non-existent at picking time, with the

result that the healthiest crop within recent years was picked. During hop-picking, the weather (at any rate in the south-east of England) was remarkably dry, and there was an absence of wet morning mists, so favourable for the spread of Downy Mildew to the cones.

## Experiment on the Treatment of the Hill.

For this purpose 8 rows of hops in Wye Field hop garden were selected ; 4 rows, alternating with the others, were left untreated and 4 were dusted with copper-lime dust on 3 April when the hills were cut and were still exposed. The dust was applied by shaking a muslin bag over the hills and from ¾ oz. to 1 oz. was applied to each.

A second dusting was given on 19 April when the shoots were 3-4 inches high and the same quantity of dust was used.

All basal spikes on the four treated and four untreated rows were collected and counted from 18 April until 30 May. From the treated rows 411 spikes were collected and 512 from the untreated, a result very similar to that obtained in 1932 and not offering any prospect of an appreciable reduction of the number of basal spikes being secured by the use of copper-lime dust on the hill.

## Weather in Relation to the Disease.

As stated elsewhere in this article, the exceptionally fine and dry season of 1933 played the most important part in suppressing the Downy Mildew. The fungus requires moist conditions for its rapid spread and these were lacking at the critical times of the growing season. It is well known that impressions of the dryness or wetness of any particular season are easily gained from experience in a short part of that season and these impressions are consequently liable to be inaccurate. Examination of the rainfall records for 1933 (Table I.) shows that while in April the total rainfall was slightly below the normal (at the usual time for the production of basal spikes) it was about half-an-inch above the normal in both May and June when it rained on half the total days in those months. As a result of this, it may be assumed, terminal spikes made an appearance in some quantity when the bines were about as high as the breast-wire and a late development of basal spikes occurred. The dry periods occurred in the first half of April, the middle week of May and the first ten days of June and at that time the condition of the soil in hop gardens was dry and dusty. The last part of June was showery but dry weather conditions were resumed at the beginning of July, the only rain in that month falling between the 8th and 16th. August was exceptionally hot and dry, a small quantity of rain falling on only nine days in the whole month. It was not until 11 September that the wet weather set in but not in time to cause any revival in the activity of the fungus.

## Summary.

1. The attacks of Downy Mildew were severe on the bine in the early part of the season, both in the form of " basal spikes " and later, in May, as " terminal spikes ", and in certain districts in Kent, Hampshire and Worcestershire, the growth of the bine was seriously damaged.

TABLE I.

*Rainfall at Wye,‡ Kent, in Relation to Hop Downy Mildew.*

| | | 1 Wye, Kent. No. of days on which rain fell.* | | | | | 2 Wye, Kent. No. of days on which 0·01 inch or more of rain fell. | | | | | 3 Wye, Kent. Total Rainfall in inches. | | | | | 4 Wye, Kent. Deviation from normal of SE. England. Inches. 1932. | 5 S.E. England. Normal mean rainfall.† Inches. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Month. | Days. | 1929. | 1930. | 1931. | 1932. | 1933. | 1929. | 1930. | 1931. | 1932. | 1933. | 1929. | 1930. | 1931. | 1932. | 1933. | | |
| April .. | 30 | 15 | 17 | 21 | 26 | 10 | 11 | 15 | 17 | 23 | 9 | 1·29 | 1·69 | 3·59 | 2·51 | 1·27 | −0·42 | 1·69 |
| May .. | 31 | 12 | 19 | 18 | 24 | 17 | 7 | 16 | 12 | 19 | 14 | 1·38 | 3·93 | 2·07 | 2·80 | 2·30 | +0·53 | 1·77 |
| June .. | 30 | 15 | 11 | 14 | 8 | 15 | 12 | 5 | 9 | 6 | 13 | 1·81 | 1·12 | 0·80 | 1·08 | 2·37 | +0·48 | 1·89 |
| July .. | 31 | 11 | 21 | 20 | 16 | 13 | 8 | 18 | 14 | 12 | 11 | 0·90 | 2·64 | 2·79 | 4·00 | 1·85 | −0·32 | 2·17 |
| Aug. .. | 31 | 10 | 19 | 25 | 11 | 9 | 7 | 13 | 19 | 8 | 7 | 2·15 | 3·04 | 3·06 | 1·19 | 0·88 | −1·44 | 2·32 |
| Sept. .. | 30 | 5 | 25 | 19 | 24 | 13 | 3 | 21 | 12 | 18 | 13 | 1·19 | 4·60 | 1·75 | 2·42 | 4·28 | +2·15 | 2·13 |

* Including those days on which a fall of rain was actually observed, but the amount was too small to be measured, i.e. less than 0·01 inch.

† Derived from weekly normals for SE. districts (1881-1915). The meteorological station at Wye has not been long established.

‡ The figures for Wye are derived from the reports of the Meteorological Office of the Air Ministry. We are indebted to Mr. J. L. Hunt, in charge of the observations at Wye, for this information.

2. In the latter part of the season, the phenomenally hot, dry weather of June, July and August reduced the fungus, generally speaking, to a barren (non-sporing) condition, and a healthy crop of hops was secured in all districts.

3. It is worthy of note that even in so hot and dry a Summer as that of 1933, the disease could be found lurking in the form of partly dried-up terminal or lateral spikes or as minute patches of spores on the under surface of the leaves of lateral shoots high up in the " heads " of bines. It is most probable that had the weather turned wet in August, some attack on the cones would have taken place in unsprayed gardens.

4. In 1933 some three-quarters of the hop acreage was sprayed as a preventive measure with Bordeaux mixture. In the light of the experience of the past season, growers are strongly advised to give at least the three routine applications of home-made Bordeaux mixture to all their hops in 1934, no matter how hot and dry the season may be.

# STUDIES ON THE OVICIDAL ACTION OF WINTER WASHES—1933 TRIALS

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An investigation of the ovicidal properties of tar and petroleum oils by laboratory and field methods has been continued during 1933 and the present communication is a further account of this work on the same lines as those already published in this *Journal* (Austin, Jary and Martin, 1932 and 1933). Laboratory tests have been concerned with the relation between the ovicidal properties of the oils and their physical and chemical characteristics, using the technique previously described (Austin, Jary and Martin, 1932, 1933) on the eggs of the Common Green Capsid Bug, *Lygus pabulinus* Linn.

The main purposes of the field trials were the examination of field methods of emulsification for the preparation of winter washes and the substantiation of the results of laboratory tests under field conditions and against a wider range of insect eggs.

## 1. Laboratory Trials.

The first object of the laboratory trials was the further investigation of the relationships between ovicidal properties and the physical and chemical characteristics of high-boiling petroleum oils. The results obtained in 1932 showed that the ovicidal property, as judged by the action of the oils on eggs of *L. pabulinus*, was independent of the base of the oil and, within the range tested, of its degree of refinement. The results further suggested that oils of higher viscosity may be less efficient as ovicides, though statistical analysis of the results established no significant correlation. It appeared also that certain oils may be deficient in ovicidal properties for reasons unrelated to differences in the physical and chemical characteristics determined.

To test the validity of these conclusions, the same samples of oils were used for the 1933 tests but, in view of the high percentage of eggs killed by washes containing 5 per cent of oil in the 1932 trials, the oil content was reduced to 4 and 2 per cent. Additional samples of oil were also obtained similar in specification to three of the oils which, from the results obtained in 1932, were considered to be better ovicides than the oils used in previous field trials. The ovicidal properties of these oils were also compared in field trials.

A second line of investigation followed by laboratory methods concerned the reasons for the difference in ovicidal efficiency between hydrocarbon oils of tar and petroleum origin. Previous work has shown that the tar oils are less ovicidal to capsid eggs than petroleum oils to a degree which appeared inconsistent with the conclusion that the chemical character of the hydrocarbons was unimportant in determining ovicidal properties. There was, however, a large difference in the boiling ranges of the tar and petroleum oils previously used and in order to make the oils more comparable on this basis, samples of cruder petroleum oils than those previously used were included.

The effect of certain chemical treatments on the ovicidal efficiency of the tar oils was also examined, to extend the range of chemical differences in the oils tested.

In earlier work the currant twigs treated were of the variety Fay's Prolific and, in order to permit of a wider application of the results and to investigate possible differences in ovicidal action due to the variety of currant in which the eggs were laid, cuttings of the variety Versailles were used. We are indebted to Mr. J. Amos, of the East Malling Research Station, for the supply of currant cuttings. The twigs, tied in small bundles, were embedded in moist soil in the open until required for treatment. Ten twigs of each variety, chosen at random from the bulk, were immersed in the wash contained in a glass cylinder, care being taken to prevent creaming of the emulsions by periodic shaking of the cylinder. When dry, the twigs were bedded in pots of damp sand, five in a pot, and the pots were placed in a cinder bed out of doors. The twigs in treatments 1-21 (see Table 1) were dipped on 20 February and placed out of doors on 21 February; treatments 22-30 were made on 22 February and the pots placed out of doors the next day. Heavy snow fell on 21-22 February but the results indicate that this had little effect on the high degree of control given by the washes containing 4 per cent of oil. The pots remained in the cinder bed until 31 March when they were removed to a cool glasshouse. Hatching of the capsids occurred over the period 7 April to 22 May, the peak of emergence occurring 14-17 May. Subsequently the twigs were peeled and counts made of the eggs which had failed to hatch and those from which capsids had emerged.

The oil emulsions used were all prepared by the two solution oleic acid method (Martin, 1931) and, in addition to the oil, 0·6 per cent by volume oleic acid and 0·1 per cent sodium hydroxide were present as the emulsifier. All the oils gave good emulsions by this method though in some cases a slight tendency to cream was observed.

(a) *The influence of variety of currant on ovicidal action.*

One hundred twigs of each variety of red currant were left untreated in the experiment. The fact that normal hatching took place under the conditions of the experiment is shown in the following figures:—Fay's Prolific contained 152 eggs, of which 151 hatched; Versailles contained 90 eggs, all of which hatched. A full list of the oils used and the sum totals per set of ten twigs, of eggs and unhatched eggs per variety, is given in Table 1. It is evident that there is a close agreement between the relative number of eggs killed in the two varieties by any one wash and the results were statistically examined by estimation of the correlation coefficient. For this calculation it was necessary to adjust the total eggs treated in each pair of results to a common figure and in order to reduce the error introduced by artificially raising the number of eggs treated, the least common multiple of the total eggs treated was chosen. For example, in experiment 5b, three of the fourteen eggs in the variety Fay's Prolofic and three of the eight eggs in the variety Versailles, were killed. For estimation of the correlation coefficient these figures were increased to twelve and twenty-one out of fifty-six, respectively. Those experiments in which, with both varieties, all or none of the eggs hatched, were omitted from the calculation. The correlation coefficient obtained, "r" $=0{\cdot}9417$, exceeds that (approximately 0·26) required for a significance corresponding to $P=0{\cdot}05$ by so large an amount that the error introduced by the artificial adjustment of the number of eggs treated cannot affect its significance to an important extent. It may therefore be concluded that no difference in ovicidal efficiencies has arisen through the use of two varieties of red currants and for subsequent examination the results in each experiment may be combined to give a total of twenty twigs.

TABLE I.

| Exp. no. | Concentration and code letter of oil used. | Fay's Prolific. | | Versailles. | |
|---|---|---|---|---|---|
| | | Total eggs. | Eggs unhatched. | Total eggs. | Eggs unhatched. |
| 1a | 6% T7 | 9 | 1 | 8 | 1 |
| 1b | 4% T7 | 32 | 0 | 7 | 0 |
| 2a | 6% T8 | 16 | 0 | 9 | 1 |
| 2b | 4% T8 | 10 | 0 | 3 | 0 |
| 3a | 6% T7a | 17 | 8 | 1 | 0 |
| 3b | 4% T7a | 13 | 5 | 11 | 5 |
| 3c | 2% T7a | 24 | 0 | 14 | 0 |
| 4a | 6% T7b | 9 | 6 | 4 | 3 |
| 4b | 4% T7b | 13 | 6 | 15 | 4 |
| 4c | 2% T7b | 11 | 0 | 6 | 0 |
| 5a | 6% T9 | 10 | 4 | 7 | 4 |
| 5b | 4% T9 | 14 | 3 | 8 | 3 |
| 5c | 2% T9 | 2 | 0 | 5 | 0 |
| 6a | 6% P3a | 11 | 9 | 5 | 4 |
| 6b | 4% P3a | 15 | 13 | 5 | 4 |
| 6c | 2% P3a | 6 | 1 | 9 | 1 |
| 7a | 6% P18 | 15 | 9 | 4 | 3 |
| 7b | 4% P18 | 9 | 6 | 4 | 3 |
| 7c | 2% P18 | 11 | 0 | 9 | 1 |
| 8a | 4% P18a | 16 | 15 | 12 | 8 |
| 8b | 2% P18a | 8 | 1 | 8 | 0 |
| 9a | 4% P19 | 10 | 8 | 10 | 8 |
| 9b | 2% P19 | 7 | 3 | 13 | 5 |
| 10a | 4% P10a | 9 | 9 | 9 | 8 |
| 10b | 2% P10a | 8 | 7 | 6 | 3 |
| 11a | 4% P12a | 21 | 21 | 8 | 8 |
| 11b | 2% P12a | 7 | 5 | 0 | 0 |
| 12a | 4% P4a | 12 | 10 | 5 | 5 |
| 12b | 2% P4a | 13 | 7 | 1 | 1 |
| 13a | 4% P17 | 19 | 18 | 13 | 12 |
| 13b | 2% P17 | 11 | 2 | 11 | 0 |
| 14a | 4% P13 | 9 | 9 | 4 | 4 |
| 14b | 2% P13 | 14 | 0 | 5 | 0 |
| 15a | 4% P6 | 9 | 4 | 3 | 2 |
| 15b | 2% P6 | 2 | 0 | 7 | 1 |
| 16a | 4% L2 | 14 | 12 | 9 | 9 |
| 16b | 3% L2 | 0 | 0 | 6 | 4 |
| 16c | 2% L2 | 9 | 4 | 5 | 2 |
| 16d | 1% L2 | 18 | 0 | 6 | 1 |

TABLE 1.—*Continued.*

| Exp. no. | Concentration and code letter of oil used. | Fay's Prolific. Total eggs. | Fay's Prolific. Eggs unhatched. | Versailles. Total eggs. | Versailles. Eggs unhatched. |
|---|---|---|---|---|---|
| 17a | 4% P14 | 14 | 12 | 5 | 5 |
| 17b | 2% P14 | 6 | 3 | 5 | 2 |
| 18a | 4% P7 | 8 | 8 | 13 | 11 |
| 18b | 2% P7 | 10 | 8 | 4 | 4 |
| 19a | 4% P12 | 9 | 9 | 9 | 8 |
| 19b | 2% P12 | 11 | 2 | 9 | 4 |
| 20a | 4% L6 | 13 | 12 | 6 | 6 |
| 20b | 2% L6 | 11 | 7 | 3 | 3 |
| 21a | 4% P10 | 9 | 8 | 5 | 5 |
| 21b | 2% P10 | 14 | 1 | 3 | 0 |
| 22a | 4% P9 | 10 | 10 | 8 | 8 |
| 22b | 2% P9 | 6 | 1 | 2 | 0 |
| 23a | 4% P11 | 19 | 19 | 5 | 4 |
| 23b | 2% P11 | 7 | 3 | 3 | 1 |
| 24a | 4% P3 | 10 | 9 | 11 | 8 |
| 24b | 2% P3 | 8 | 2 | 7 | 2 |
| 25a | 4% L3 | 12 | 12 | 6 | 5 |
| 25b | 2% L3 | 21 | 0 | 3 | 0 |
| 26a | 4% P8 | 19 | 19 | 14 | 14 |
| 26b | 3% P8 | 9 | 9 | 6 | 5 |
| 26c | 2% P8 | 9 | 4 | 7 | 3 |
| 26d | 1% P8 | 10 | 1 | 4 | 0 |
| 27a | 4% L5 | 9 | 9 | 24 | 24 |
| 27b | 2% L5 | 6 | 5 | 7 | 7 |
| 28a | 4% P2 | 10 | 8 | 6 | 5 |
| 28b | 2% P2 | 12 | 5 | 12 | 6 |
| 29a | 4% P4 | 15 | 15 | 18 | 17 |
| 29b | 3% P4 | 12 | 8 | 7 | 7 |
| 29c | 2% P4 | 6 | 2 | 10 | 2 |
| 29d | 1% P4 | 9 | 1 | 11 | 0 |
| 30a | 4% L4 | 18 | 16 | 10 | 8 |
| 30b | 3% L4 | 8 | 2 | 3 | 0 |
| 30c | 2% L4 | 10 | 1 | 4 | 1 |
| 30d | 1% L4 | 11 | 0 | 17 | 0 |

(*b*) *Petroleum oils of different characteristics as ovicides.*

To simplify the examination of the results and their comparison with those obtained in 1932, the same method of presentation has been used. Dealing first with the high boiling petroleum oils, comparisons were made of the ovicidal action ot oils, all of asphaltic base, selected in pairs, of which one oil differs from the other in one characteristic but is approximately similar in the remaining properties. The characteristics of the oils used are given in Table 3 of the 1932 report but, instead of the semi-refined oil P5 which has too high a viscosity to be suitable for use in commercial washes, an oil

of similar degree of refinement to P5, but of viscosity similar to L6, was substituted. The characteristics of this oil, called P17, are given in Table 2 and the results of counts of hatched and unhatched eggs appear in Table 3.

TABLE 2.

| | P17 | P4a | P10a | P12a |
|---|---|---|---|---|
| Sp. Gr. (60° F.) | 0·931 | 0·898 | 0·905 | 0·897 |
| Viscosity, Redwood 1 @ 70° F. | 870″ | 167″ | 542″ | 168″ |
| Boiling range: | | | | |
| 1st drop | 364° C. | 330° C. | 346° C. | 333° C. |
| 10% by volume | 381 | 348 | 366 | 345 |
| 20% ,, | 389 | 357 | 378 | 355 |
| 30% ,, | 395 | 364 | 390 | 362 |
| 40% ,, | 401 | 369 | 398 | 370 |
| 50% ,, | — | 377 | — | 378 |
| 60% ,, | — | 385 | — | 386 |
| 70% ,, | — | 392 | — | 394 |
| Unsulphonated residue. % by volume | 58·3 | 74·2 | 86·7 | 73·3 |

TABLE 3.

| | At 4 per cent. | | | At 2 per cent. | | |
|---|---|---|---|---|---|---|
| | Hatched. | Unhatched. | $\chi^2$. | Hatched. | Unhatched. | $\chi^2$. |
| (1) Oils of different viscosity or boiling range but of similar iodine value or unsulphonated residue. | | | | | | |
| L3 | 0 | 18 | 2·81 | 24 | 0 | 3·6 |
| L4 | 4 | 24 | | 12 | 2 | |
| P3 | 4 | 17 | 3·92 | 11 | 4 | 0·01 |
| P4 | 1 | 32 | | 12 | 4 | |
| (2) Oils of similar viscosity or boiling range but of different iodine value or unsulphonated residue. | | | | | | |
| L5 | 0 | 33 | 6·8 | 1 | 12 | 12·3 |
| P3 | 4 | 17 | | 11 | 4 | |
| L2 | 2 | 21 | 0·85 | 8 | 6 | 0·03 |
| P2 | 3 | 13 | | 13 | 11 | |
| L6 | 1 | 18 | 0·02 | 4 | 10 | 14·96 |
| P17 | 2 | 30 | | 20 | 2 | |

The differences in ovicidal action are expressed in Table 3 as $\chi^2$: on the assumption that the eggs are of a uniform population the difference may be regarded as significant if $\chi^2$ exceeds 3·841. The results show little agreement with those obtained in 1932 and there is no indication that in 1933 the physical factors of boiling range and viscosity have exerted a greater influence on ovicidal power than the chemical factor determined by the degree of refinement. The main differences between the 1932 and 1933 results may, however, be accounted for by the failure of the P3 oil during the latter season. Whereas this oil in 1932 completely inhibited egg hatching at 3 per cent and was a significantly better ovicide than P4, in 1933 it did not kill all the eggs treated even at 4 per cent and at this concentration appeared to be less ovicidal than the P4 oil. Further, in 1932 no difference was shown by the oils P3 and L5, whereas in 1933 the oil P3 was definitely inferior as an ovicide to the oil L5.

(*c*) *The ovicidal action of semi-refined oils of different bases.*

The tests of semi-refined oils of different bases were repeated in 1933 and additional samples were included of the oils P10 and P12 which the 1932 results suggested were better ovicides than the oils P2 and P4 and which were compared with these oils in field trials in 1933. These additional samples called P10a and P12a were bought from the same oil refiner under the same code number. P4a was an oil of the same specification and code number as the oil P4 used in the 1932 trials. The results of counts of hatched and unhatched eggs are shown in Table 4, which is to be compared with Table 6 of the 1932 report.

TABLE 4.

| | At 4 per cent. | | | At 2 per cent. | | |
|---|---|---|---|---|---|---|
| | Hatched. | Unhatched. | $\chi^2$. | Hatched. | Unhatched. | $\chi^2$. |
| Paraffinic base oils. | | | | | | |
| P6 .. | 6 | 6 | 6·81 | 8 | 1 | 12·4 |
| P7 .. | 2 | 19 | | 2 | 12 | 5·7 |
| P8 .. | 0 | 33 | | 9 | 7 | |
| Naphthenic base oils. | | | | | | |
| P9 .. | 0 | 18 | | 7 | 1 | |
| P10 .. | 1 | 13 | | 16 | 1 | 16·3 |
| P10a .. | 1 | 17 | | 4 | 10 | |
| P11 .. | 1 | 23 | | 6 | 4 | |
| Western base oils. | | | | | | |
| P12 .. | 1 | 17 | | 14 | 6 | 3·7 |
| P12a .. | 0 | 29 | | 2 | 5 | |
| P13 .. | 0 | 13 | | 19 | 0 | |
| P14 .. | 2 | 17 | | 6 | 5 | |

In the 1933 results the oils P11 and P13 at 3 per cent stood out as markedly inferior to the other oils tested, but this inferiority is not shown at 4 per cent in the 1933 tests. At this concentration the oil P6 would appear to be deficient in ovicidal properties. Considering the results with sprays of oil concentration 2 per cent, there is a significant difference between the oils P10 and P10a in their behaviour as ovicides although these oils are of similar specification. The oil P13 would again appear to be of low ovicidal value, but this deficiency is not so marked as that shown in the results at 3 per cent in 1932. On the other hand the oil P7 has given a high degree of control which was not indicated in 1932. It is impossible to detect any general difference in ovicidal properties related to the base of the oil.

(*d*) *The correlation of ovicidal properties and characteristics.*

Calculation of the correlation coefficient between the viscosity and the ovicidal properties, as measured by the percentage hatched of the eggs treated, of the eighteen samples of oils used in the 1932 tests, gave a value " r " 0·392, though the omission of the results obtained with the highly viscous oil P5 reduced this figure to 0·191. A similar calculation for the 1933 results, including the oil P17 instead of P5 and the additional samples P10a and P12a, yields the figure " r " 0·144 for 4 per cent oil concentration and 0·007 for 2 per cent oil concentration. It may hence be concluded that the viscosity and those physical properties of the oils tested, such as boiling range and

specific gravity, which are related to viscosity, have no influence on the ovicidal properties toward eggs of *L. pabulinus*. The correlation coefficient between the percentage hatched and the chemical properties of the oils as indicated by the percentage unsulphonated residue is " r " 0·138 for 4 per cent oil concentration and 0·244 for 2 per cent oil concentration. The conclusion, in agreement with that reached last year, is, therefore, that the degree of refinement bears no relationship to the ovicidal properties of the oils tested on the eggs of *L. pabulinus*.

(*e*) *The ovicidal inefficiency of tar oils.*

The results obtained in 1931 and 1932 showed that the tar oils tested were decidedly inferior to the group of petroleum oils used, for killing eggs of *L. pabulinus*. This inferiority seems to be out of agreement with the conclusion that the degree of refinement of hydrocarbon oils has no influence on their ovicidal properties. Two possible explanations of this apparent discrepancy are evident. The crudest of the petroleum oils examined has an unsulphonated residue of about 60 per cent, whereas, if the degree of refinement of the tar oils used were to be indicated in a like manner, this figure would be 0 per cent. The tar oils might then be considered beyond the range of saturated hydrocarbon content of the petroleum oils from which this experimental conclusion was deduced. A second possible explanation may be found in the difference between the boiling ranges of the tar and petroleum oils examined, for, since that of the tar oils is lower on the average by about 20° C., it could be suggested that the lower ovicidal efficiency is related to greater loss by volatility.

To test the correctness of the former explanation, trials were made with a petroleum oil of low content of saturated hydrocarbons and with samples of tar oils which had been subjected to treatment for the purpose of increasing their hydrocarbon content. The petroleum oil of low unsulphonated residue, described in Table 5 under P18, was a high boiling sulphurdioxide soluble fraction isolated by the Edeleanu process., When washed with dilute sodium hydroxide, this oil yielded 2·6 per cent by weight of alkali-soluble material, the greater part of which was precipitated on the addition of barium chloride. Acidification of this precipitate and extraction with ether yielded 2·2 per cent acids resembling naphthenic acids in their ability to form soap-like alkali salts. The alkali and acid-soluble constituents were removed to give a second sample of this oil P18a.

Two samples of tar oils T7 and T8 were used as received from the tar distillers. They were produced by the distillation of tar obtained from the carbonization of Durham coal in high temperature by-product coke ovens. The former of these was also subjected to further treatment with the object of removing constituents of a non-hydrocarbon nature. The ether solution of the oil was washed with dilute alkali and subsequently with dilute acid to remove tar acids and tar bases, the neutral oil, T7a, being recovered by evaporation of the solvent. The oil T7b was obtained from T7a by dissolving the latter in light petroleum (B.P., 40° C.) and treating with successive additions of hydroferrichloric acid reagent (Martin, 1933) to remove oxygenated derivatives. This treatment was continued until no further sludge separated when the oil T7b was recovered by evaporation of the light petroleum. T7b was a half-white oil of characteristics shown in Table 5, but it rapidly darkened in colour after isolation.

In overcoming the difference in the boiling ranges of the tar and petroleum oils examined, a difficulty arises through the solidification of the tar oils of boiling range above 260-380° C. It was, however, found that, by treatment of the light petroleum

solution of the neutral oils with hydroferrichloric acid, a tar oil was obtained which could be distilled to give a fraction boiling above 320° C. which did not solidify on standing. Heavy yellow crystals were deposited from which the oil was decanted. The boiling range of this oil approximates closely to that of many of the petroleum oils used in the tests, e.g. L2, L3, L5 and P18. To obtain a petroleum oil of lower boiling range for comparison with the usual tar oils, the oil P3 was distilled and the fraction 320-360° C. was collected. The boiling range of this oil is shown under P3a in Table 5.

The results of counts of hatched and unhatched eggs from twigs treated with these oils are shown in Table 6. From these results it is apparent that the tar oils T7 and T8 have again shown a markedly lower ovicidal efficiency than the petroleum oils and that the treatment of the tar oil T7 has given oils of greater ovicidal powers. That the removal of tar acids and tar bases has improved its ovicidal powers towards the eggs of *L. pabulinus* is in agreement with the laboratory observations of Tutin (1927) that the neutral oils are better ovicides than the untreated oil against the eggs of *Aphis pomi* and *Cheimatobia brumata* and the similar conclusion arrived at by Staniland, Tutin and Walton (1930) from field trials against the eggs of the apple capsid bug, *Plesiocoris rugicollis*. The increase in toxicity following the removal of the tar acids and bases and of oxygenated derivatives appears to be greater than can be accounted for by increase in the hydrocarbon content brought about by the treatments. Thus the tar oil T7 contains 89 per cent of neutral oils which in turn yield 75 per cent of oil after treatment with hydroferrichloric acid. The oil T7 at 6 per cent is therefore equivalent to the oil T7b at 4·005 per cent, and the figures for egg hatch, namely 15 out of 17 for T7 at 6 per cent, and 18 out of 28 for T7b at 4 per cent, although not showing a significant difference ($\chi^2 = 3 \cdot 1$), indicate that the T7b oil may be the more ovicidal. It is therefore suggested that the failure of the tar oils as ovicides against *L. pabulinus* is associated with their greater content of constituents of a non-hydrocarbon character.

TABLE 5.

| Percentage by weight. | Tar oils. | | | | | Petroleum oils. | | |
|---|---|---|---|---|---|---|---|---|
| | T7 | T7a | T7b | T8 | T9 | P3a | P18 | P18a |
| Neutral oils | 89·1 | 100·0 | 100·0 | 92·0 | 100·0 | 100·0 | 96·2 | 100·0 |
| Tar acids | 5·0 | 0·0 | 0·0 | 2·9 | 0·0 | 0·0 | 2·6* | 0·0 |
| Tar bases | 6·3 | 0·0 | 0·0 | 4·2 | 0·0 | 0·0 | 0·3† | 0·0 |
| Sp. Gr. (60° F.) | 1·107 | 1·094 | 1·083 | 1·097 | 1·101 | 0·866 | 1·003 | 0·991 |
| Viscosity, Redwood 1 @ 70° F. | 104″ | 50″ | 51″ | 312″ | 139″ | 76″ | 355″ | 197″ |
| Boiling range: | | | | | | | | |
| 1st drop | 215°C. | 214°C. | 225°C. | 210°C. | 304°C. | 278°C. | 299°C. | 300°C. |
| 10% by volume | 261 | 270 | 264 | 254 | 325 | 307 | 320 | 321 |
| 20% ,, | 282 | 290 | 283 | 278 | 332 | 315 | 330 | 330 |
| 30% ,, | 302 | 306 | 297 | 300 | 340 | 322 | 340 | 342 |
| 40% ,, | 315 | 320 | 311 | 318 | 347 | 326 | 351 | 351 |
| 50% ,, | 328 | 333 | 322 | 334 | 354 | 332 | 359 | 360 |
| 60% ,, | 340 | 346 | 335 | 349 | 364 | 339 | 370 | 370 |
| 70% ,, | 354 | 361 | 348 | 361 | 374 | 347 | 380 | 381 |
| 80% ,, | 370 | 380 | 365 | 373 | 387 | 357 | 394 | 395 |
| Unsulphonated residue, % by vol. | — | — | — | — | — | 91·9 | 14 | 14·5 |
| Methyl sulphate, % by vol. insol. | 0·0 | 0·0 | 0·0 | 0·0 | 0·0 | 100·0 | 77·0 | 70·0 |

* = soluble in 2 per cent sodium hydroxide.
† = soluble in 4 per cent hydrochloric acid.

Considering now the behaviour of the hydrocarbons as ovicides, the tar oils T7b and T9 consist mainly of aromatic hydrocarbons and yield 0 per cent unsulphonated residue, the oils P18 and P18a are, from their method of isolation, mainly aromatic and unsaturated hydrocarbons, yielding only 14 per cent unsulphonated residue, whereas the oil P3a, which has an unsulphonated residue of 92 per cent, consists mainly of saturated hydrocarbons. The results shown in Table 6 indicate a significant superiority of P3a over T9 at both 6 and 4 per cent and over T7b at 4 per cent, and they further suggest that the oils P18 and P18a are intermediate in ovicidal properties between P3a and the tar oils. It may tentatively be concluded, therefore, that oils of low content of saturated hydrocarbons have inferior ovicidal properties towards eggs of *L. pabulinus*. The evidence already dealt with in sections (*b*), (*c*) and (*d*) indicates that this inferiority may not become of importance until the unsulphonated residue of the oil falls below 60 per cent by volume. The failure of the tar oils tested may thus be associated with the chemical constitution of the hydrocarbons present.

TABLE 6.

| Oil. | At 6 per cent. | | | At 4 per cent. | | | At 2 per cent. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Hatched. | Un-hatched. | $\chi^2$. | Hatched. | Un-hatched. | $\chi^2$. | Hatched. | Un-hatched. | $\chi^2$. |
| T8 | 24 | 1 | | 13 | 0 | | — | — | |
| T7 | 15 | 2 | | 39 | 0 | | — | — | |
| | | | 4·58 | | | 19·3 | | | |
| T7a | 10 | 8 | | 14 | 10 | | 38 | 0 | |
| | | | 1·87 | | | 0·2 | | | |
| T7b | 4 | 9 | | 18 | 10 | | 17 | 0 | |
| | | | 1·26 | | | 3·2 | | | |
| P18 | 7 | 12 | | 4 | 9 | | 19 | 1 | |
| | | | 0·94 | | | 5·9 | | | 1·1 |
| T9 | 9 | 8 | | 16 | 6 | | 7 | 0 | |
| | | | 4·07 | | | 17·7 | | | 0·1 |
| P3a | 3 | 13 | | 3 | 17 | | 13 | 2 | |
| P18a | — | — | | 5 | 23 | | 15 | 1 | |

Concerning the possibility that the inferior ovicidal properties of the tar oils is associated with their lower boiling range, the results given in Table 6 show that the petroleum oil P3a, an oil of lower boiling range than the tar oil T9, is more ovicidal. Further, the oil T9 at 4 per cent is of definitely lower ovicidal power than the petroleum oils L2 ($\chi^2=23\cdot5$), L3 ($\chi^2=21\cdot8$), L5 ($\chi^2=33\cdot9$) and P3 ($\chi^2=12\cdot6$) which are of similar boiling range. The lower boiling range cannot, therefore, fully account for the lower ovicidal efficiency of the tar oils to eggs of *L. pabulinus* when compared to petroleum oils.

(*f*) *The correlation between ovicidal action and oil content.*

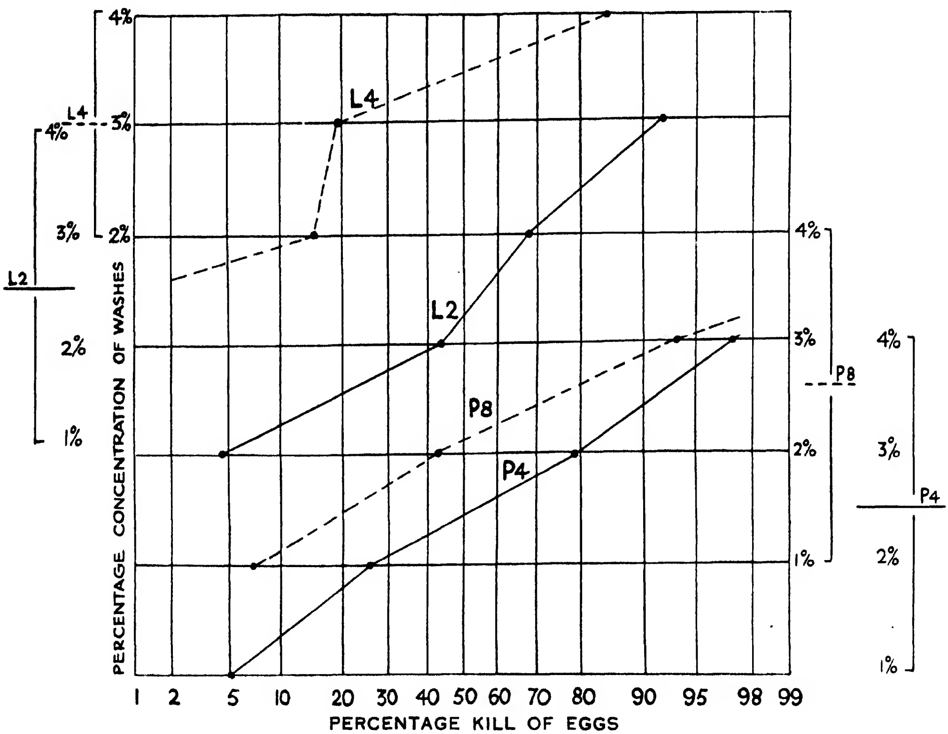
Preliminary trials were made in 1933 for the investigation of the relationships between ovicidal properties and the oil content of the petroleum oil washes. The petroleum oils L2, L4, P4 and P8 were chosen as representative samples of high boiling oils of high and low degree of refinement and of high and low viscosity, and they were employed at concentrations of 4, 3, 2 and 1 per cent. Table 7 gives the results of egg counts expressed as total number of eggs treated and percentage killed. When plotted on squared paper against concentration, the percentage killed give sigmoid curves

which, transferred to arithmetic probability paper yield, with the exception of the oil L4, straight lines (Fig. 1). This result, though based on insufficient data to justify a definite conclusion, suggests that the ovicidal efficiency of the oils is directly proportional to the concentration of the oil when the effect of variations in the susceptibility of the eggs is obviated.

TABLE 7.

| Percentage of oil. | L2 | | P8 | | P4 | | L4 | |
|---|---|---|---|---|---|---|---|---|
| | Total eggs. | Percentage kill. | Total eggs. | Percentage kill. | Total eggs. | Percentage kill. | Total eggs. | Percentage kill. |
| 4 per cent .. | 23 | 91·3 | 33 | 100·0 | 33 | 97·0 | 28 | 85·7 |
| 3 per cent .. | 6 | 66·7 | 15 | 93·3 | 19 | 78·9 | 11 | 18·2 |
| 2 per cent .. | 14 | 42·9 | 16 | 43·7 | 16 | 25·0 | 14 | 14·3 |
| 1 per cent .. | 24 | 4·2 | 14 | 7·1 | 20 | 5·0 | 28 | 0·0 |

FIG. 1.




An interesting point is that the straight lines given on probability paper do not appear to be parallel and this feature was further investigated in the main series by a comparison of the relative toxicities of 4 and 2 per cent concentrations of the same oil. If the average percentage kill at 4 and 2 per cent of the twenty-one petroleum oils be calculated, the deviation from these averages for each oil at the two concentrations fails

to show a significant correlation between percentage kills at 4 and 2 per cent. A similar calculation for the twenty-eight oils used at 4 and 2 per cent gives "r" 0·4554, a figure exceeding that (0·3809) appropriate for P 0·05 and indicating a significant correlation. With the twenty-one petroleum oils alone the absence of a significant correlation between the percentage kill at 4 and 2 per cent suggests that the oils do not show the same relative toxicity at different concentrations. As the criterion of relative toxicity, the difference between percentage kills at 4 and 2 per cent was accepted on the assumption that this difference is proportional to the tangent of the angle between the ordinate and the percentage kill-concentration curve at the 50 per cent kill point. This figure shows no relation either to viscosity or to the degree of refinement of the oils. It is, however, difficult to attribute the variations in relative toxicity entirely to experimental error.

2. Field Trials.

At two centres the trials were in the nature of a demonstration of the ease with which a grower can prepare for himself a winter wash containing oils of a given specification. In both cases the wash was applied to black currants of the variety Baldwin for the control of *Lygus pabulinus*.

The wash contained 4 per cent of strained anthracene oil and 6 per cent of a semi-refined, high boiling petroleum oil, emulsified by the two-solution oleic acid method, and it was similar in composition to those washes which had been found very successful for the control of *L. pabulinus* in the 1931 and 1932 trials. The grower purchased direct the required amounts of tar and petroleum oils, brown commercial oleic acid and flake caustic soda and, after one demonstration, was left to prepare the wash as required from these ingredients. The method used was as follows:—For 100 gallons of wash, thoroughly mix 4 gallons of strained anthracene oil, 6 gallons of petroleum oil and 1 gallon of oleic acid in a suitable container. Into a 100-gallon tank, put about 80 gallons of water and stir in 1½ lb. of caustic soda (supplied in 1 lb. lever-lid tins). Stir the oil-oleic acid mixture into the dilute caustic soda solution and complete the total volume to 100 gallons with water.

This wash was applied at one centre to 9 acres of Baldwins on 14-17 February by means of a small power machine. This broke down before the acreage was completed and the work was finished with knapsacks. When visited on 4 April, buds were breaking normally and no sign of injury was observed. The field was again inspected on 19 May, when it was apparent that a good commercial control of *L. pabulinus* had been obtained. A few capsid-marked shoots were found which were in the area under treatment when the power machine failed. A possible explanation is that the bushes in this area may have been inadequately covered with the wash.

At the second centre the wash was applied entirely with knapsack machines to 4 acres of the variety Baldwin on 18 February. An inspection on 4 April revealed no evidence of injury to the bushes and a second inspection on 19 May showed that an excellent control of the capsid had been obtained for, in spite of a thorough search, no trace of leaf marking was found. It is worthy of record that these bushes had been so heavily attacked in previous years that they had made very little wood growth and were to be grubbed as unprofitable.

The field trials proper were arranged for the testing of certain oils which the results of the 1932 laboratory tests indicated were of greater ovicidal efficiency than the semi-refined oil used in the above field demonstrations. The characteristics of these oils are shown in Table 2, page 118, and in order to permit a better comparison of their ovicidal values, they were applied at 4·5 per cent instead of 6 per cent.

(*a*) *Red Currants.*

We are indebted to Mr. T. Neame, Macknade, Faversham, for permission to use a block of red currants of the variety Fay's Prolific for this trial. The whole adjacent acreage, other than the experimental block, has been washed with a proprietary tar-petroleum oil wash. The experimental block was divided into a Latin square of twenty-five plots, each plot containing 5 × 5 bushes, with the exception of the outside column in which the plots were of 5 × 4 bushes. Strained anthracene oil T10 was included in all the washes, which, in addition to 1·15 per cent sodium oleate as the emulsifier, were composed of the following oils :—

T10P4a (10%) .. 4 per cent strained anthracene oil and 6 per cent petroleum oil P4a.

T10P4a (7·5%) .. 3 per cent strained anthracene oil and 4·5 per cent petroleum oil P4a.

T10P10a (7·5%) 3 per cent strained anthracene oil and 4·5 per cent petroleum oil P10a.

T10P12a (7·5%) 3 per cent strained anthracene oil and 4·5 per cent petroleum oil P12a.

The washes were applied on 10 February by means of a power machine operating two lances, under excellent weather conditions. When visited on 4 April, the whole block appeared to be slightly less advanced in growth than the remainder of the field, but since there was no difference between the sprayed and unsprayed plots in this respect, the slight retardation must have been due to other factors, among which must be reckoned the fact that the field, other than the experimental block, was interplanted with strawberries. In estimating the ovicidal value of the washes on 19 May, three bushes were chosen at random from the middle 3 × 3 bushes of each plot. Each bush was examined by an independent observer who counted the number of shoots carrying leaves marked by the capsid and, on the unsprayed plots, the total number of shoots on the bushes were also counted. The results are shown in Table 8, together with the lay-out of the plots.

TABLE 8.

| | | | | |
|---|---|---|---|---|
| T10P10a 7·5% 3 ; 1 ; 2 | T10P12a 7·5% 3 ; 1 ; 2 | T10P4a 7·5% 0 ; 5 ; 5 | Unsprayed 18/51 39/48 19/28 | T10P4a 10% 9 ; 6 ; 9 |
| T10P12a 7·5% 2 ; 0 ; 2 | Unsprayed 33/42 13/47 22/42 | T10P4a 10% 1 ; 4 ; 3 | T10P4a 7·5% 1 ; 12 ; 3 | T10P10a 7·5% 0 ; 7 ; 4 |
| T10P4a 10% 6 ; 0 ; 1 | T10P10a 7·5% 6 ; 1 ; 4 | Unsprayed 19/37 42/58 27/40 | T10P12a 7·5% 5 ; 3 ; 3 | T10P4a 7·5% 30 ; 7 ; 21 |
| Unsprayed 22/48 18/41 22/49 | T10P4a 7·5% 6 ; 11 ; 12 | T10P10a 7·5% 7 ; 9 ; 17 | T10P4a 10% 2 ; 2 ; 1 | T10P12a 7·5% 0 ; 10 ; 19 |
| T10P4a 7·5% 3 ; 1 ; 7 | T10P4a 10% 3 ; 3 ; 3 | T10P12a 7·5% 6 ; 3 ; 7 | T10P10a 7·5% 3 ; 3 ; 0 | Unsprayed 11/40 38/47 38/46 |

If these results are combined to give the total number of capsid-marked shoots per 15 bushes, the following figures are obtained :—

| | |
|---|---|
| Unsprayed .. .. .. .. .. | 381 shoots marked out of 664. |
| T10P4a (10%) .. .. .. .. | 53 capsid-marked shoots. |
| T10P4a (7·5%) .. .. .. .. | 124 capsid-marked shoots. |
| T10P10a (7·5%) .. .. .. .. | 67 capsid-marked shoots. |
| T10P12a (7·5%) .. .. .. .. | 66 capsid-marked shoots. |

A statistical analysis of the individual results, omitting the figures obtained from unsprayed bushes, shows no difference in the ovicidal value of the four washes.

(*b*) *Black Currants.*

The late Sir W. Berry, Gushmere Court, Faversham, kindly gave us permission to use a block of bushes of the variety Baldwin for this trial. The block, adjacent to that used in 1932, was divided into a Latin square of twenty-five plots, each plot containing 5 × 5 bushes. The whole field had previously been washed with a proprietary tar oil winter wash, so that the experimental washes used contained petroleum oils only, for the control of *L. pabulinus*. The oils were all emulsified by the oleic acid method and therefore, in addition to the oil, contained 1·15 per cent of sodium oleate. Instead of the oil P4a, the oil P15 was used, this oil being taken from the barrel used in the 1932 trials, of which the analysis is given in Table 11, page 72 of the 1932 report (Austin, Jary and Martin, 1933). The washes used were as follows :—

P15 (6%) ; P15 (4·5%) ; P10a (4·5%) and P12a (4·5%).

They were applied on 9 February with a small power machine operating three lances. The weather conditions were dry but rather windy, and nozzle trouble occurred on one of the P10a plots, the bushes of which were inadequately covered. No indication of any wash damage was seen when the plots were visited on 4 April. On 19 May the degree of capsid infestation was estimated by three independent observers who counted, on a bush selected at random from the middle 3 × 3 bushes of each plot, the number of shoots showing capsid-marked leaves. The bushes were too large to permit the counting of the total shoots on the unsprayed bushes and on these and also on some of the sprayed bushes an estimate was made of the percentage of shoots with capsid markings. The results and lay-out of the trial are given in Table 9.

The P10a (4·5%) plot showing 100 per cent infestation is the one noted above as being inadequately covered with wash. For the statistical examination of the counts, the results for the entire fourth column were therefore omitted, together with the estimates for the unsprayed plots. Further, for this analysis, the counts denoted as (> 50) in the P12a plots were counted as 50, an assumed improvement in ovicidal efficiency which was negligible as the P12a was proved inferior by the subsequent analysis. With these modifications the combined totals of capsid-marked shoots per twelve bushes are :—

| | |
|---|---|
| P15 (6%) .. .. .. .. .. | 238 capsid-marked shoots. |
| P15 (4·5%) .. .. .. .. | 424 capsid-marked shoots. |
| P10a (4·5%) .. .. .. .. | 238 capsid-marked shoots. |
| P12a (4·5%) .. .. .. .. | 508 capsid-marked shoots. |

TABLE 9.

| | | | | |
|---|---|---|---|---|
| P12a<br>4·5%<br>51 ; 70 ; 46 | P10a<br>4·5%<br>27 ; 17 ; 38 | Unsprayed<br><br>100% | P15<br>4·5%<br>25 ; 35 ; 65 | P15<br>6%<br>7 ; 10 ; 4 |
| P10a<br>4·5%<br>9 ; 8 ; 3 | P15<br>6%<br>4 ; 12 ; 13 | P12a<br>4·5%<br>(>50) ; 43 ; 40 | Unsprayed<br>100%<br>(2 shoots unmarked) | P15<br>4·5%<br>24 ; 13 ; 37 |
| Unsprayed<br><br>100% | P12a<br>4·5%<br>37 ; 47 ; (>50) | P15<br>4·5%<br>43 ; 39 ; 81 | P15<br>6%<br>27 ; 35 ; 37 | P10a<br>4·5%<br>14 ; 23 ; 21 |
| P15<br>4·5%<br><br>16 ; 38 ; 46 | Unsprayed<br>100%<br>(1 shoot unmarked) | P15<br>6%<br><br>60 ; 32 ; 46 | P10a<br>4·5%<br><br>100% | P12a<br>4·5%<br><br>20 ; 12 ; 42 |
| P15<br>6%<br>12 ; 15 ; 23 | P15<br>4·5%<br>27 ; 27 ; 33 | P10a<br>4·5%<br>18 ; 18 ; 42 | P12a<br>4·5%<br>42 ; 52 ; 56 | Unsprayed<br><br>100% |

The analysis of variance, given in Table 10, indicates a significant difference as "$z$" exceeds 0·6757, the figure appropriate for P 0·05. The significant difference, calculated from the composite standard error, for the totals of twelve bushes, is 158·6 shoots and it may therefore be concluded that the washes P15 (6%) and P10a (4·5%) have given a better control of the capsid than the washes P15 (4·5%) and P12a (4·5%).

TABLE 10.

| Variance due to | Degrees of freedom. | Variance $\sigma^2$. | $\frac{1}{2}\log_e\sigma^2$. | "$z$." |
|---|---|---|---|---|
| Washes .. .. | 3 | 1542·00 | 3·67046 | 0·72417 |
| Columns .. .. | 3 | 1162·50 | — | |
| Interaction .. | 9 | 362·30 | 2·94629 | |
| Error .. .. | 32 | 125·40 | — | |

(c) *Trials on apples.*

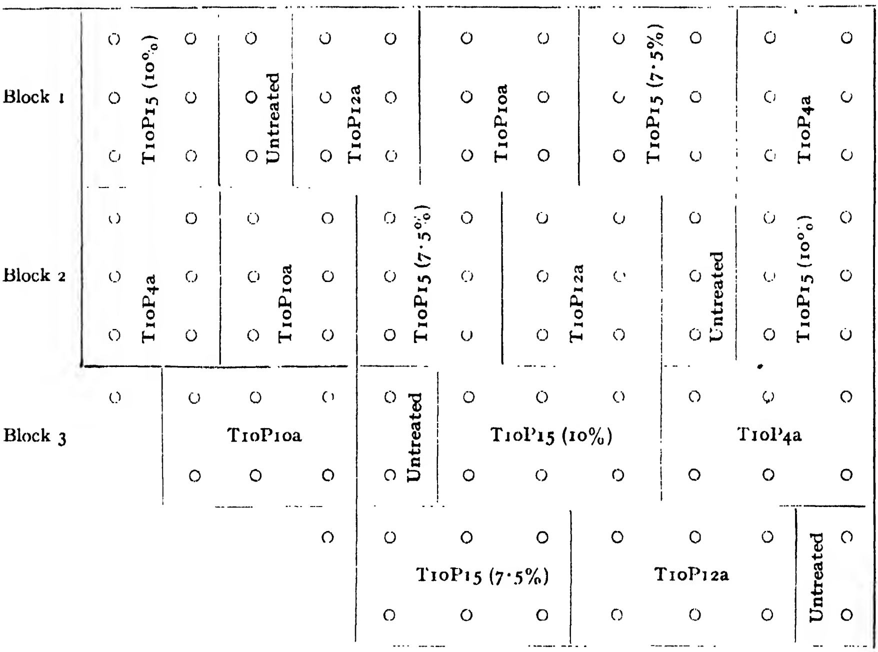
Four field trials were carried out on the use of tar and petroleum oils as winter washes for apples. The first was designed for a comparison of the efficiencies of the four petroleum oils P15, P4a, P10a and P12a, used on currants, for the control of the Apple Capsid Bug, *Plesiocoris rugicollis* ; the second was intended for an investigation of the causes of bud damage which had been observed in the previous year's trials, by the application of a tar-petroleum oil wash containing 10 per cent of oil, to trees of the variety Lane's Prince Albert ; in the third trial, a mixed orchard in which the trees were badly infested with Apple Sucker, *Psylla mali*, was used for the comparison of the ovicidal efficiency of a home prepared tar oil wash with that of certain proprietary washes; the fourth trial was a demonstration of the home preparation of a combined tar-petroleum oil wash as a general winter wash.

(i) *Worcester Pearmain Apples.*—We are again indebted to Mr. E. Vinson, Kemsdale, Faversham, who placed at our disposal the trees used in trials (i) and (ii). A block of 102 trees of the variety Worcester Pearmain, adjacent to the block used for trial in 1932, was divided into three blocks of five plots, each with six trees. As shown in Fig. 2,

four smaller plots, in all ten trees, were left untreated and the remainder received the following washes :—

| | |
|---|---|
| T10P15 (10%) | 4 per cent strained anthracene oil T10 and 6 per cent petroleum oil P15. |
| T10P15 (7·5%) | 3 per cent T10 and 4·5 per cent P15. |
| T10P4a .. | 3 per cent T10 and 4·5 per cent P4a. |
| T10P10a .. | 3 per cent T10 and 4·5 per cent P10a. |
| T10P12a .. | 3 per cent T10 and 4·5 per cent P12a. |

FIG. 2.




The oils, particulars of which have already been given, were all emulsified by the oleic acid method and the washes therefore contained 1·15 per cent sodium oleate as the emulsifier. They were applied on 8 February with a power machine operating three lances under good weather conditions, though wind caused a noticeable but not serious amount of drift. Fifty gallons of each wash was applied and the two trees shown in Fig. 2, outside the plots, were washed with T10P10a wash.

It was evident when the plots were inspected on 20 April that serious damage had been caused to the blossom buds by the wash containing 10 per cent of oil, on blocks 2 and 3. On block 1, however, the damage and retardation, though apparent, was not nearly so serious. On 10 May estimates were made of the number of trusses showing

capsid-marked leaves, on each of four trees selected at random in each plot. All the unsprayed trees were similarly examined. The average number of marked trusses per tree was as follows :—

| | |
|---|---|
| T10P15 (10%) .. .. .. .. | 6·1 capsid-marked trusses. |
| T10P15 (7·5%) .. .. .. .. | 24·8 capsid-marked trusses. |
| T10P4a .. .. .. .. .. | 25·5 capsid-marked trusses. |
| T10P10a .. .. .. .. .. | 22·8 capsid-marked trusses. |
| T10P12a .. .. .. .. .. | 10·1 capsid-marked trusses. |
| Untreated .. .. .. .. | > 77 capsid-marked trusses. |

The analysis of variance, from which the counts on untreated trees were omitted, is shown in Table 11, and indicates that there is a significant difference between the washes. The significant difference calculated from the composite standard error is 12·5 capsid-marked trusses per tree. The washes T10P15 (10%) and T10P12a are therefore superior to the washes T10P15 (7·5%), T10P4a and T10P10a, in reducing capsid infestation.

TABLE 11.

| Variance due to | Degrees of freedom. | Variance $\sigma^2$. | $\frac{1}{2}\log_e\sigma^2$. | "z." |
|---|---|---|---|---|
| Blocks .. .. | 2 | 969·3 | — | |
| Washes .. .. | 4 | 992·7 | 3·450216 | 0·723822 |
| Interaction .. | 8 | 203·2 | — | |
| Error .. .. | 45 | 233·4 | 2·726394 | |

This conclusion was confirmed by the results obtained from fruit grading which was carried out 16-17 and 30-31 August. All fruits showing even slight capsid marking were placed in the marked grade. The totals from the individual plots in each treatment and the percentage capsid-marked are given in Table 12.

TABLE 12.

| Washes. | Block 1. | | Block 2. | | Block 3. | | Total. | | |
|---|---|---|---|---|---|---|---|---|---|
| | Total. | % marked. | Total. | % marked. | Total. | % marked. | No. | % marked. | Weight lb. |
| Untreated | 1292 | 8·0 | 1222 | 34·2 | 1838 | 43·0 | 4352 | 30·2 | 776 |
| T10P15 (10%) | 2377 | 7·0 | 1338 | 2·0 | 1672 | 0·8 | 5387 | 3·8 | 998 |
| T10P15 (7·5%) | 2630 | 18·2 | 2347 | 15·3 | 1914 | 5·5 | 6891 | 13·7 | 1178 |
| T10P4a | 2844 | 16·4 | 1698 | 22·7 | *1496 | 8·4 | 6038 | 16·2 | 1032 |
| T10P10a | 2907 | 7·0 | 2833 | 13·8 | 2103 | 13·0 | 7843 | 11·1 | 1270 |
| T10P12a | 2972 | 8·2 | 2618 | 5·0 | 2593 | 2·6 | 8183 | 5·4 | 1476 |

* Only 4 trees included.

The analysis of variance of these figures, from which counts from untreated trees have been omitted, reveal a significant difference due to washes. Calculation of the

average percentage capsid-marked fruit per plot and of the significant difference shows that the washes T10P15 (10%) and T10P12a are better ovicides than the others.

| | |
|---|---|
| T10P15 (10%) .. .. .. .. | 3·27% capsid-marked. |
| T10P15 (7·5%) .. .. .. .. | 13·00% capsid-marked. |
| T10P4a .. .. .. .. .. | 15·83% capsid-marked. |
| T10P10a .. .. .. .. .. | 11·27% capsid-marked. |
| T10P12a .. .. .. .. .. | 5·27% capsid-marked. |

Significant difference = 9·98% capsid-marked.

The phytocidal action of the T10P15 (10%) wash is indicated by the figures obtained for the total crop of apples per plot. The analysis of variance of the average number of apples per tree per treatment, including the untreated trees, reveals a significant difference due to washes :—

| | |
|---|---|
| Untreated .. .. .. .. | 432 apples per tree. |
| T10P15 (10%) .. .. .. .. | 299 apples per tree. |
| T10P15 (7·5%) .. .. .. .. | 383 apples per tree. |
| T10P4a .. .. .. .. .. | 377 apples per tree. |
| T10P10a .. .. .. .. .. | 436 apples per tree. |
| T10P12a .. .. .. .. .. | 454 apples per tree. |

Significant difference = 119 apples per tree.

The 10 per cent oil wash has therefore caused a reduction of total crop and it is interesting to note that this reduction was apparently greater in the plots of blocks 2 and 3 than in block 1.

TABLE 13.

| Percentage by weight. | Wash "A". | Wash "B". Strained anthracene oil T10. | Wash "C". | Wash "D". |
|---|---|---|---|---|
| Neutral oils .. .. .. .. | 67·0 | 57·5 | 66·2 | 71·7 |
| Tar acids .. .. .. .. | 0·5* | 4·6 | 0·2* | 10·3 |
| Tar bases .. .. .. .. | 0·3† | 4·3 | 0·1† | 2·9 |
| Total oil .. .. .. .. | 67·8 | 66·4 | 66·5 | 84·9 |
| Of neutral oils, Sp. Gr. (60° F.) .. | 0·995 | 1·093 | 0·919 | 0·996 |
| Boiling range : | | | | |
| 1st drop .. .. .. .. | 300° C. | 240° C. | 305° C. | 230° C. |
| 10% by volume .. .. .. | 323 | 273 | 324 | 262 |
| 20% ,, .. .. .. | 333 | 294 | 334 | 282 |
| 30% ,, .. .. .. | 343 | 310 | 342 | 299 |
| 40% ,, .. .. .. | 351 | 325 | 350 | 320 |
| 50% ,, .. .. .. | 360 | 336 | 358 | 336 |
| 60% ,, .. .. .. | 369 | 348 | 366 | 350 |
| 70% ,, .. .. .. | 381 | 359 | 376 | 368 |
| 80% ,, .. .. .. | 395 | 371 | 387 | 386 |
| Methyl sulphate, % by vol. insol. .. | 73 | 0 | 88 | 41 |
| Unsulphonated residue, % by vol. .. | 22 | 0 | 62 | 29·5 |

* = soluble in 2 per cent sodium hydroxide.
† = soluble in 4 per cent hydrochloric acid.

(ii) *Lane's Prince Albert Apples.*—The four rows of four trees left unsprayed in the 1932 trials were used in an attempt to determine the causes of the severe blossom bud damage which was observed in that year on neighbouring trees sprayed with various tar-petroleum oil washes. It was thought possible that the high oil concentration (10 per cent) might of itself be a sufficient explanation of the damage or that the combination of tar and petroleum oil might be more phytocidal than either oil alone. Two series of experiments were accordingly carried out; in one the washes were applied at 10 per cent oil concentration, i.e. 10 per cent strained anthracene oil T10, 10 per cent petroleum oil P15 and a combination of 4 per cent strained anthracene oil and 6 per cent petroleum oil; in the other the oils were applied at concentrations of 6 per cent, the combined wash containing 2·4 per cent tar oil and 3·6 per cent petroleum oil.

To reduce error due to tree variation, each tree was divided into four quarters, three of which were washed with the various concentrations and the fourth left untreated. The same wash was applied to eight trees, the quarter receiving any particular wash being selected at random. The washes were applied 8 February by means of a knapsack machine and the parts of the tree not receiving that particular wash were screened by sheets. Observations made on the trees throughout April and May revealed no difference between the washed and unwashed quarters in regard to blossom and foliage development. A few isolated buds were dead but they were not sufficient in number to warrant counts. The absence of phytocidal action may have been due to the careful application of the washes at relatively low pressure and it appears possible that much of the injury associated with tar and petroleum oil washes is due to the very heavy application often given, resulting in the over-washing of some parts of the trees.

(iii) *Mixed Varieties.*—The mixed orchard used in this trial was kindly placed at our disposal by Mr. V. G. Burgess of Goudhurst. On account of the complex varietal arrangement, shown in Fig. 3, which gives part of the sprayed plots, no attempt was made at replicated trials. The washes used were intended solely for the control of Apple Sucker, *Psylla mali*, of which there was a uniform infestation throughout the orchard. The washes comprised a home-prepared tar oil wash which contained 4 per cent of the strained anthracene oil T10 and three proprietary winter washes which were applied at 6 per cent. Those labelled " A " and " C " are of interest as they were stated to contain no tar oil, the makers having used instead a petroleum oil rich in unsaturated and aromatic hydrocarbons as the toxic ingredient for the control of aphides and apple sucker. The eggs of these are not affected by the usual semi-refined and half-white petroleum oils used in winter washes. Wash " C " contained a proportion of this oil in addition to a refined petroleum oil and in this respect resembled the DP15 wash used in the 1932 trials (Austin, Jary and Martin, 1933), in which a diesel oil of 87 percentage insolubility in methyl sulphate was used instead of strained anthracene oil. As in the 1932 trials the DP15 wash gave a poor control of aphis, it seemed doubtful whether wash " C " would be satisfactory and the makers supplied for experimental purposes the wash " A " in which the oil is entirely that of high aromatic hydrocarbon content. The wash " D ", supplied by the grower, was a well-known brand labelled " Standard Tar oil ". The low specific gravity, the high percentage insoluble in methyl sulphate and the high percentage of unsulphonated residue, shown in Table 13, indicate that the oil present in this material was a tar-petroleum mixture containing at least 40 per cent of petroleum oil. It has been usual, as shown by the analyses of " standard " tar oil washes given on page 80 of the account of the 1931 trials (Austin, Jary and Martin, 1932), for manufacturers to include up to 10 per cent petroleum oils in such washes, but

the high proportion of petroleum oil in wash " D " was unexpected. It will be observed that the strained anthracene oil also has an unusually low total oil content. This oil was purchased from the tar distiller on the basis of a satisfactory sample and was used in the wash before a check analysis could be made from the bulk. When this was made, it showed the presence of undue quantities of water and sodium hydroxide in the oil, which the tar distillers ascribed to an accident. In spite of its high alkali content, which was equivalent to 2 per cent by weight sodium hydroxide, the oil emulsified readily by the two-solution method, although a marked increase in viscosity occurred when it was mixed with the oleic acid.

When the orchard was visited on 28 April, no evidence of damage by the washes was apparent and it was seen that an excellent control of aphis and apple sucker had been obtained with washes " B " and " D ". Estimates were made of the percentage of blossom trusses infested with one or more apple suckers but, because of the scarcity of blossom, only the bush trees were examined. The figures given in Table 14 were obtained from these.

TABLE 14.

| Variety. | Wash " A ". | Wash " B ". | Wash " C ". | Wash " D ". |
|---|---|---|---|---|
| Beauty of Bath .. .. .. | 10 | Trace * | — | 0 |
| Lane's Prince Albert .. .. | 40 | 0 | 60 | 0 |
| Lord Derby .. .. .. | 20 | — | 20 | 0 |

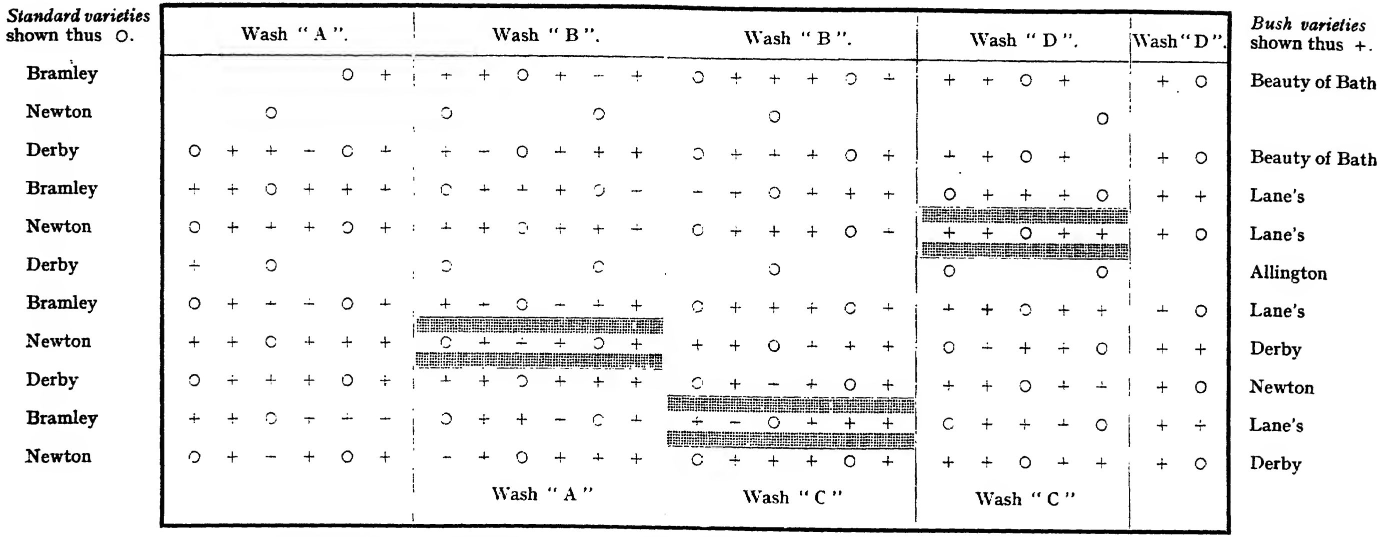
* Only two infested trusses were found.

The inferior ovicidal properties of washes " A " and " C " may be attributed to the low content of aromatic hydrocarbons, as expressed by the percentage of neutral oil soluble in methyl sulphate which, calculated from the figures in Table 13, are :— " A " 1·09 per cent, " B " 2·30 per cent, " C " 0·48 per cent, and " D " 2·54 per cent.

(iv) *Miller's Seedling, Worcester Pearmain and Bramley's Seedling.*—We are indebted to A. Amos, Esq., Spring Grove, Wye, for permission to use part of a plantation at Bekesbourne for this demonstration of the home-prepared tar-petroleum oil winter wash as a general wash for apples. The wash contained 3 per cent strained anthracene oil T10 and 4·5 per cent semi-refined petroleum oil P4a. Emulsification was carried out by the two-solution oleic acid method as described in the section dealing with trials on currants above. After one demonstration of the method of mixing, the men were left to prepare and apply 1,000 gallons of wash. This operation was carried out on 6 February, a stationary power machine working two lances being employed.

When inspected on 6 May, a few buds were observed to have suffered apparent damage and the same was noted on trees of the same varieties on either side, where two different proprietary washes had been used. An excellent control of the eggs of aphides and winter moths had been obtained and the trees blossomed well and subsequently carried full crops. A small amount of infestation by *Lygus pabulinus* was noted in this plantation, but it was so irregular in distribution as to make counts worthless. There was no greater infestation of this insect on the trees treated with the home-prepared wash than on others, and all through the season there was no evidence that its effects were inferior to those of the proprietary washes.

Fig. 3.




Trees between the shaded bands received spray drift from two different washes and these trees were disregarded in making an examination of the effect of the washes.

## Summary.

1. Laboratory tests of the ovicidal efficiency of various tar and petroleum oils on the eggs of the common green capsid *Lygus pabulinus* Linn. gave the following results :—

(*a*) No differences due to the variety of currant were observed in the action of the oils on eggs laid in twigs of Fay's Prolific and Versailles.

(*b*) No relationship was found between ovicidal properties and the characteristics of twenty-one petroleum oils of paraffinic, asphaltic, naphthenic and Western bases, of viscosities ranging from 126″ to 800″ Redwood 1 at 70° F. and of unsulphonated residues ranging from 60 to 100 per cent by volume.

(*c*) The ovicidal efficiency of a tar oil was improved by the removal of tar acids and bases but treatment for the removal of oxygenated derivatives did not give a tar oil of ovicidal efficiency equal to that of a half-white petroleum oil of a similar boiling range.

(*d*) Evidence was obtained of the lower ovicidal efficiency of petroleum oils of unsulphonated residue below 60 per cent by volume and it is suggested that the inferiority of tar oils as compared to the petroleum oils tested is associated, apart from lower hydrocarbon content and boiling range, with the chemical character of the hydrocarbons present.

(*e*) The relative ovicidal efficiencies of the various petroleum oils examined at 4 per cent and at 2 per cent show differences unassociated with the characteristics of the oils determined.

2. Field trials showed the two-solution oleic acid method of emulsification suitable for the preparation, by the grower himself, of washes containing tar and petroleum oils of specified characteristics.

3. Home-prepared washes containing 3 per cent of strained anthracene oil and 4·5 per cent of one of four petroleum oils of different characteristics,

(*a*) applied to red currants, equalled in the control of the capsid *Lygus pabulinus* a wash containing 4 per cent of tar oil and 6 per cent petroleum oil ;

(*b*) applied to black currants, failed to equal the control of *L. pabulinus* given by the 10 per cent combined oil wash, except in the case of one petroleum oil (P10a) ;

(*c*) applied to Worcester Pearmain apples, failed to equal the control of the capsid *Plesiocoris rugicollis* obtained with the 10 per cent combined oil wash, except in the case of one petroleum oil (P12a). Marked bud damage was caused by the 10 per cent combined oil wash.

4. A home-prepared wash containing 4 per cent strained anthracene oil gave an excellent control of the apple sucker, *Psylla mali*, which was equalled by a proprietary wash used at 6 per cent. The failure to control apple sucker of two proprietary washes containing, instead of tar oil, a petroleum oil of low unsulphonated residue, was found to be related to the low content of aromatic hydrocarbons in the prepared wash.

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# THE CONTROL OF APPLE SCAB: ALLINGTON PIPPIN AND NEWTON WONDER, 1933

By W. Goodwin, H. Martin, E. S. Salmon and W. M. Ware.

Since 1927 spraying experiments against Scab have been carried out in one of the apple plantations at the South-Eastern Agricultural College, Wye, Kent. A detailed account of these experiments has been given annually in this *Journal*, and a summary of the results obtained during the five years 1927-31 was contained in No. 30 of the same publication (p. 61).

It was decided to compare, in the season of 1933, the fungicidal efficiency of home-made Bordeaux mixture with a vegetable oil-Bordeaux emulsion. There are reasons for belief that an oil-Bordeaux emulsion can safely be applied in a heavy wash on apple foliage, whereas the ordinary Bordeaux mixture must be applied in a fine, misty spray—an operation requiring more time. Further, on chemical grounds, it seems possible that a less amount of copper for fungicidal efficiency will be required in oil-Bordeaux emulsions and that spray injuries may be avoided. Moreover, as vegetable oils have been discovered to be fungicidal to the Hop Powdery Mildew, it is probable that a vegetable oil-Bordeaux emulsion may prove to be of value in controlling Apple Powdery Mildew as well as Scab. In 1932 mustard oil was used; in 1933 cotton-seed oil.

The trees in Plot A were sprayed with 8 : 12 : 100 Bordeaux mixture (8 lb. copper sulphate, 12 lb. hydrated lime, 100 gals. water) and, for reasons given in our Report for 1931 (this *Journal*, No. 30, p. 60), four applications were given—two pre-blossom and two post-blossom. The trees in Plot B were used for trials with the oil-Bordeaux emulsion. The oil used was a cheap edible cotton-seed, obtained from the Olympia Oil & Cake Co., Ltd., of Selby. Because of its low content of free fatty acid (equivalent to less than 0·3 gm. oleic acid per 100 ml.), the oil was used at a concentration of 0·75 per cent, in order to adjust the actual glyceride content of the spray to that of the expressed oil of mustard emulsion used in 1932. The improved retention of the copper-containing deposit resulting from the presence of the oil* permits a reduction of the concentrations of copper sulphate and lime used for the preparation of the wash to one-half those used in ordinary Bordeaux mixture. For the preparation of the wash six pints of the cotton-seed oil and four gallons of 10 per cent copper sulphate (bluestone) solution were added simultaneously to 95 gallons of water containing 6 lb. of hydrated lime. The oil readily emulsified without the formation of the green scum observed with the mustard oil wash used in 1932.†

The small motor-propelled spraying machine described in our last account of these trials was again used in 1933. One man guided and managed the machine and in company with one other carried buckets of the spray fluid to replenish the tank when required. Two men did the spraying, using 6-ft. Drake & Fletcher bamboo rods fitted with single nozzles and new No. 1 discs. The pressure maintained was about 200 lb.

The first pre-blossom spraying was on 13 April with bright sunshine and a light wind from the North. All trees were heavily sprayed until the branches dripped and the work was rapidly completed. Plot A (ordinary Bordeaux mixture) received

* See Martin, H.: in *Ann. Appl. Biol.*, XX, 342 (1933).
† See this *Journal*, No. 32, 95 (1933).

52 gallons in 50 minutes (2·2 gallons per tree in 4·2 man-minutes) and Plot B (oil-Bordeaux emulsion) 52 gallons in 48 minutes (1·9 gallons per tree in 3·6 man-minutes).

The plantation was well cultivated and free from weeds; no dead leaves were found on the ground except on a grass path at the south end. The Allington buds were slightly more advanced than those of the Newtons and individual blossom buds were separating in the truss; here and there the calyx was spreading and showing the pink colour of the tightly closed petals. About five leaves were expanded in the rosettes of the wood buds and lambourdes. The Newtons were in the green bud stage with all blossom buds enclosed by the calyx and tightly grouped in the truss; around this the leaves were fully expanded. Many of the trees of this variety bore no blossom buds and the wood buds were only just unfolding; consequently there was very little foliage to spray. No Scab was found in either variety, perhaps on account of the continuous dry weather from 21 March to 12 April.

The second pre-blossom ("pink-bud") spraying was on 26 April with a rather strong and gusty breeze from the South and with a cloudy sky that threatened rain. Plot A (Bordeaux mixture) was sprayed first and was finished in 35 minutes. Drake & Fletcher 6-ft. bamboo rods were used, fitted with single "Mistifier" nozzles well screwed down and with No. 1 discs. The volume of spray was very satisfactory and 39 gallons were used (1·6 gallons per tree in 2·9 man-minutes). For Plot B, arsenate of lead* was added to the oil-Bordeaux emulsion at the rate of 2 lb. to the 100 gallons; the nozzles were unscrewed slightly but the same No. 1 discs were used and 62 gallons of the spray fluid were applied in 34 minutes (2·3 gallons per tree in 2·5 man-minutes). The control plots were sprayed with arsenate of lead on the same day.

The Allington trees were in the pink-bud stage with no flowers open; the state of the blossom in the Newtons was more variable, some trees being in the pink-bud stage and others less advanced. Five or six leaves of the lambourde buds and wood buds were expanded. Very slight injury in the form of purple spotting was present to a slight extent on all leaves (in Plot A only) and was due to the first spraying on 13 April. The absence of Scab in the whole plantation may be accounted for by the continuation of dry weather up to a day or two before this spraying. Recent showers that had occurred, however, were thought likely to induce the first infections of the season and that therefore Scab might be expected to make its appearance within about a fortnight.†

On 12 May, when the quantity of blossom present on the different trees could be estimated, it was found that all the Allingtons in Plot A and in the control plots were practically devoid of blossom, while in Plot B six of the twelve trees were moderately well covered. In the Newtons, the following numbers of trees were entirely without blossom:—Plot 1 (6 trees) 1; Plot 2 (6 trees) 1; Plot 3 (2 trees) 2; Plot A (12 trees) 7; Plot B (15 trees) 6. This fact explains the small crop figures obtained, more especially in the case of the Allingtons. Reference to the notes made on individual trees in 1932 showed that each Newton tree was continuing the phenomenon of blossom production only in alternate seasons.

On 23 May the first post-blossom spraying was carried out under calm conditions with warm sunshine. All the petals had fallen about a week previously and it was considered, therefore, that the spraying was somewhat late. On this occasion, nicotine was added to the spray mixtures in both plots (8 oz. per 100 gallons). Plot A required

* Owing to lateness of arrival, the arsenate of lead had to be omitted from the Bordeaux mixture in Plot A.

† The next close inspection of the plantation was not until twenty-seven days later (i.e. on 23 May) when it was found that Scab was by then well established.

36 minutes and 44 gallons of Bordeaux mixture were applied by means of single nozzles well screwed down and fitted with No. 1 discs (1·8 gallons per tree in 3·0 man-minutes). Plot B required 52 minutes and 121 gallons of oil-Bordeaux emulsion were applied by means of the same single nozzles, unscrewed, and fitted with No. 2 discs (4·5 gallons per tree in 3·9 man-minutes).

*Allington.*—Most of the foliage was borne on dards and lambourdes, there being little new wood. Spray injury in the form of purple spotting of some of the outer leaves of the lambourdes was noticeable in Plot A. The few new wood shoots were from 3 inches to 9 inches long with 9-12 leaves and purple spotting was present occasionally on the lowest three leaves. Scab was very rare but single areas of infection were present here and there on leaves not yet sprayed in both Plots A and B. No yellowing or defoliation had resulted from the first two sprayings. In the control plots, the Scab attack was less than in the Newtons but was already established. Infection occurred, for example, on one younger leaf of lambourdes with eight leaves. On some trees many such infected lambourdes were present, making the Scab attack more evident, and some leaves were already sooty with Scab along the veins. On a few new wood shoots five of the nine leaves were infected.

*Newton.*—In Plot A, yellowing and fall of the lowest three leaves of the eight on the young wood shoots and similar injury to the leaves around the blossom trusses had resulted from the previous sprayings. Appreciable injury was recorded on those trees which had borne blossom, the trusses being left with no leaves around them. Scab was present here and there on the leaves now about to be sprayed, showing that the first post-blossom application would be already too late to act as a preventive spray. In Plot B, no spray injury occurred. Scab attack, though not yet severe, was developing rather more in this plot and brown dead areas of the laminae were to be seen as a result of infection. On some lambourdes and dards, all the leaves, including even the youngest, were infected ; on others, showing spray deposit on the four lower leaves, only the three younger unsprayed leaves were attacked. This again showed that infection had probably occurred about three weeks earlier and that the first post-blossom spraying had been too long deferred. In the control plots the Scab attack was quite obvious on approaching the trees. The areas of infection were more numerous on each leaf and the fungus was spreading along the veins. Nearly every lambourde and dard was attacked and the new wood shoots were commonly infected on any or all leaves, even including the youngest. Those trees which had blossomed were now showing some spotting of the truss leaves, especially of the younger ones borne higher up the blossom axis.

The plantation was next visited on 12 June, immediately before the fourth spraying (second post-blossom) on that day. In the interval of time since the last application, hot and dry weather conditions had persisted but in spite of this a large amount of Scab had developed.

*Allington.*—The new wood was up to 19 inches long with 20 leaves of which the lowest 8 to 11 showed spray deposit. In Plot A, it was difficult to find any of the fungus ; here and there it occurred on a sprayed leaf and was evidently killed and dried up by the spray even though it had previously succeeded in killing a certain area of the lamina. The fruit, though very scarce, was healthy ; it was marked to some extent with a corky russet and the russeted apples showed Bordeaux deposit on the skin and calyx. In Plot B there was slightly more Scab but no serious attack. The unsprayed new leaves of the wood were still healthy and what little of the fungus existed occurred as spots on the last leaves sprayed, and here it was being killed. In the control plots, a strong attack was beginning and the fungus was on any leaves of the young wood shoots up to

the third from youngest, sometimes in sooty condition. Some periodicity of attack was perhaps to be distinguished, for the lowest leaves (five to nine in number) on the shoots were commonly healthy, the next few infected, the next two or three healthy, then a few more infected and finally the three youngest healthy. In the lambourdes and dards, two or three of the rosette of seven or eight leaves and usually the youngest, were commonly attacked and it was noted that the Scab extended down the petioles of lambourde leaves as far as the bud in the centre of the rosette. Actual infection of the young bud scales was not found. Fruit was very scarce but one apple was seen with six areas of infection on the skin; each of these was ⅛-inch diameter. The largest apples were 1-inch diameter.

*Newton.*—The new wood was 9 inches long with nine leaves of which six had already been sprayed. In Plot A, on both wood shoots and dards, Scab was present on the last leaf to be sprayed and occurred amongst the deposit of Bordeaux mixture.* The fungus was also present on the next younger leaf as yet unsprayed. On the dards, where eight leaves were present, seven of these had been sprayed and the fungus was attacking both the seventh and eighth. This condition throughout the plot led to the conclusion that a wave of infection had occurred just before the last spraying, a conclusion borne out by the notes made on 23 May (see page 138). No loss of foliage was noticeable in Plot A on casual examination, but in most cases the apples were devoid of spur leaves unless a lambourde happened to be developing on the fruit-bearing prolongation of the spur. The largest apples were now 1⅛-inch diameter. In Plot B the attack of Scab was similarly developed. The new wood was rather longer than could be found in Plot A and was up to twelve inches long with fifteen leaves of which the upper six leaves were as yet unsprayed. The last two leaves to be sprayed and the next one or two awaiting spraying were infected. Here again the Scab fungus occurred in the spray deposit but, although the centre of each colony was in an active and powdery condition, the margins showed signs of being killed. The very dry weather had probably some effect in reducing the fungicidal power of both the Bordeaux mixture and the oil-Bordeaux emulsion for, in the absence of water, their toxic properties would be largely ineffective. In Plot B, no spray damage had been caused and the fruit was as yet healthy.

In the control plots a very severe attack of both Scab and Red Spider was in progress and the trees, particularly in Plot 2, were withered, the foliage being completely scorched. Only the youngest leaf of the new wood shoots was free from Scab; the remainder were commonly sooty over the whole lamina and were sometimes killed. A few apples were infected with areas of Scab ⅛-inch in diameter.

The spraying was begun in the late evening of 12 June with a dull sky and a slight breeze from the North. Plot A was sprayed with the single nozzles screwed down and fitted with No. 1 discs. The time taken was 46 minutes and 54 gallons were used (2·3 gallons per tree in 3·8 man-minutes). Only four more trees in Plot B remained to be sprayed when heavy rain rendered the work in this plot useless. On 14 June the whole of Plot B was again sprayed with oil-Bordeaux emulsion. The weather was fine and sunny with a northerly breeze. The single nozzles were unscrewed to give a larger

* The presence of the Scab fungus in close contact with a visible deposit of a fungicide has been illustrated and discussed in a previous paper (this *Journal*, No. 30, Fig. 1, p. 54 and p. 62, July 1932). In the present instance the fungus was powdery with spores on parts of leaves plentifully sprayed; it was actually growing on laminae completely covered with a fine Bordeaux film and occasionally was even forming a ring around a central "island" of the blue deposit. In some cases, the fungus, after being powdery, was becoming reddish in colour and dried up. In other cases, radiating lines of the fungus could be seen in healthy condition below the blue deposit. Presumably the fungus was beneath the cuticle.

volume of spray and No. 1 discs were used. Ideal spraying for the oil-Bordeaux emulsion was carried out with a great cloud of fog-like spray from each nozzle which half-enveloped the tree and gave perfect cover and rapid work. The spray dripped from the trees as they were finished, 100 gallons being used on this plot. The time taken in spraying was 50 minutes (3·7 gallons per tree in 3·7 man-minutes).

On 1 August, the plantation was visited. *Allington.*—The new wood was now up to 3 ft. long. In Plot A the trees were suffering from a very severe attack of Red Spider and Woolly Aphis, though it was noticed that these pests were even more harmful in Plots 2 and 3 which were unsprayed and their presence could not therefore be said to be favoured by the spraying with Bordeaux mixture. Scab was well under control but was attacking some of the newly expanded leaves which had not yet been sprayed. The very scarce fruit was healthy but was slightly russeted with dark spots of ½ mm. around the lenticels or more decidedly with a rough russeting over half the surface of the apple. Below the trees, brown dead leaves were lying on the ground. In Plot B, the attacks of Woolly Aphis and Red Spider were rather less severe than in Plot A but the trees were freer from these pests than were those in the control plots. The fruit was healthy but largely russeted on the exposed surface; on the other hand, some apples showing a distinct blue deposit, were free from russet. Scab was absent from fruit and leaves except on the youngest (unsprayed) leaves of the new wood. In the control plots, the fungus was present on most of the leaves up to the third from youngest; it was often in sooty condition and extending along the veins but was somewhat dried up. The attack was not so severe as in some years for the phenomenon of " killing through ", with prevalence of brown dead areas on the leaves, was not seen. Except for Woolly Aphis and Red Spider, which caused a rusty colour as well as leaf-drop, the trees were still green and the leaves not obviously blackened or killed by Scab. Everywhere the fungus appeared to be restrained by the dry weather conditions. The fruit was scarce but was infected to the extent of about 65 per cent, as judged by eye. Old areas of infection, now corky and brown, and also recent small black spots with white cuticle at the margin, occurred on the apples; the largest fruit was 2½ inches diameter. *Newton.*—In Plot A some leaves showed old dried-up areas of Scab infection where an earlier attack had been suppressed by the spraying and the foliage as a whole was healthy. Perhaps on account of the very dry and hot weather, there had been no extension of the disease to unsprayed foliage but there was a noticeable scarcity of both lambourdes and new wood. The very small crop was free from Scab but about 6 per cent of the apples were affected with russeting. In Plot B, Red Spider attack was bad though again not so serious as in the control plots. Scab was present only in the form of shrivelled mycelium killed by the last spraying but it had succeeded in infecting about 1 per cent of the fruit. The apples were slightly russeted where hidden or badly russeted where exposed. On only a few of the trees was there a heavy crop. In the control plots the leaves were of dull brown colour and the trees nearly defoliated by the attack of Woolly Aphis and Red Spider. Scab was present on these leaves but was in a dried-up condition. The apples had failed to grow out and were only 1 to 1½ inch diameter. About 90 per cent of them were scabbed. The new wood was only 6 inches long and was quite defoliated, the only leaves remaining on the trees being on dards or lambourdes. As a result, dormant buds were breaking into leaf.

This inspection of the plantation gave the general impression that, with both varieties, the last forceful attack by the Scab fungus had been effectively stopped by the fourth spraying in Plots A and B and that the dry weather had probably assisted in preventing any revival. Recent infections, however, on the youngest leaves and on the fruits, showed that the fungus was not by any means completely suppressed.

### Grading.

The crop was picked on 10-12 October. There was a very short crop on the Allingtons, which gave only 6 cwt., and on the Newtons, which gave 1 ton 8¼ cwt. The whole crop was graded by hand, the same method of grading being followed as in previous seasons. Grade I. consisted of apples free from Scab* ; Grade II. of apples on which Scab spots were few or many, but the fruit was not unmarketable ; Grade III. of apples so cracked or disfigured by Scab as to be unmarketable.

Table I. (1933).

| Plot and Treatment. | Variety. | No. of Trees. | No. of Apples Picked. | Percentage No. of Apples in Grades 1 | 2 | 3 | Weight Apples. lb. | Percentage Weight of Apples in Grades 1 | 2 | 3 |
|---|---|---|---|---|---|---|---|---|---|---|
| A. Hydrated Lime Bordeaux mixture 8 : 12 : 100 | Allington | 12 | 142 | 92·2 | 7·8 | — | 56 | 88·3 | 11·7 | — |
| (four times) | Newton | 12 | 2627 | 60·9 | 39·0 | 0·1 | 789 | 62·0 | 37·9 | 0·1 |
| B. Cotton-Seed Oil-Bordeaux emulsion 4 : 6 : 100 | Allington | 12 | 2163 | 92·8 | 7·2 | — | 556 | 91·4 | 8·6 | — |
| (four times) | Newton | 15* | 9181 | 64·4 | 35·5 | 0·1 | 2195 | 64·8 | 35·1 | 0·1 |
| 1. Control | Allington | 3 | 72 | 18·1 | 81·9 | — | 24 | 18·7 | 81·3 | — |
| (unsprayed) | Newton | 6 | 383 | 8·6 | 65·5 | 25·9 | 82 | 11·0 | 71·3 | 17·7 |
| 2. Control | Allington | 3 | 82 | 15·9 | 82·9 | 1·2 | 24 | 16·7 | 83·3 | — |
| (unsprayed) | Newton | 6 | 498 | 6·6 | 85·4 | 8·0 | 106 | 9·4 | 84·9 | 5·7 |
| 3. Control | Allington | 6 | 72 | 23·6 | 76·4 | — | 22½ | 20·0 | 80·0 | — |
| (unsprayed) | Newton | 2† | No crop. | | | | | | | |
| Controls together | Allington | 12 | 226 | 19·2 | 80·5 | 0·3 | 70½ | 18·4 | 81·6 | — |
| (unsprayed) | Newton | 14 | 881 | 7·5 | 76·7 | 15·8 | 188 | 10·1 | 79·0 | 10·9 |

* One of these is a small tree, about 10 feet high.
† One of the original three trees was grubbed in the Winter of 1931.

### Discussion of Results.

Allington Pippin.—The number of Scab-free apples in the three control (unsprayed) plots was 18·1, 15·9 and 23·6 per cent of the crop, giving an average of 19·2 per cent.

*Bordeaux Mixture Plot.*—In the Plot A sprayed four times with Bordeaux mixture 92·2 per cent of the apples were Scab-free, an increase in percentage of 73 over the average of the unsprayed plots. This is exactly the same increase as was shown in 1932.

*Cotton-Seed Oil-Bordeaux Plot.*—In the Plot B sprayed four times with cotton-seed oil-Bordeaux emulsion, 92·8 per cent of the apples were Scab-free, an increase in percentage of 73·6 over the average of the unsprayed plots. It is clear, therefore, that the fungicidal efficiency of the Bordeaux emulsion was not inferior to that of Bordeaux mixture.

* As many as three very minute Scab spots on an apple (each not larger than the head of pin) were not considered sufficient to reduce that fruit to the level of Grade II. Such cases were numerically very small.

NEWTON WONDER.—The number of Scab-free apples in the two control* (unsprayed) plots was 8·6 and 6·6 per cent of the crop, giving an average of 7·6 per cent. The apples in Grade II. were covered with very numerous Scab-spots, and were more severely affected than those in the same Grade in Plots A and B.

*Bordeaux Mixture Plot.*—In the Plot A sprayed four times with Bordeaux mixture, 60·9 per cent of the apples were Scab-free, an increase in percentage of 53·3 over the average of the unsprayed plots. The Scab-spots were scattered, and were less numerous round the " eye " than in Plot B.

*Cotton-Seed Oil-Bordeaux Plot.*—In the Plot B sprayed four times with cotton-seed oil-Bordeaux emulsion, 64·4 per cent of the apples were Scab-free, an increase in percentage of 56·8 over the average of the unsprayed plots. The Scab occurred mainly round the " eye ", in spots easily seen. Here again it is evident that the cotton-seed oil-Bordeaux emulsion is at least the equal of Bordeaux mixture.

## RUSSETING.

*Allington Pippin.*—In the plot sprayed with Bordeaux mixture, 13 apples, all in Grade I., were definitely russeted as the result of spraying; this represented 9·15 per cent by number of the total crop, and 9·92 per cent (by number) of the apples in Grade I. This percentage of russeting is considerably higher† than those met with previously, which have been, for the total crop, as follows :—1927, 2·7 per cent ; 1928, 3·5 per cent ; 1929, 1·2 per cent ; 1930, 1·5 per cent ; 1931, 1·46 per cent ; 1932, 2·0 per cent.

In the plot sprayed with cotton-seed oil-Bordeaux emulsion, 105 apples in Grades I. (99) and II. (6) were russeted, representing 4·85 per cent (by number) of the total crop, and 4·93 and 3·84 per cent of the apples in Grades I. and II., respectively.

*Newton Wonder.*—In the plot sprayed with Bordeaux mixture, russeting was rather common to a small extent, but the injury was so slight as to be of no commercial importance. Other apples showed the same kind of injury and were graded and counted as being definitely russeted ; these apples, 77 in number, occurred in Grades I. (61) and II. (16) and represented 2·93 per cent (by number) of the total crop, and 3·81 per cent of the apples in Grade I. This amount of russeting is similar to that obtained in 1932 (and greater than that met with in the previous five years' experiments) ; the percentage is, however, so small that the injury cannot be considered important.

In the plot sprayed with cotton-seed oil-Bordeaux emulsion, 64 apples in Grades I. (56) and II. (8) were definitely russeted, representing 0·70 per cent (by number) of the total crop and 0·95 per cent of the apples in Grade I.—an entirely negligible amount.

The figures for russeted fruit show that less damage was caused to the apples on trees washed with the oil-Bordeaux emulsion than on trees sprayed with Bordeaux mixture. It is of interest to note that the spray retention figures show that this effect is not due to a lower amount of copper retained on the washed trees.

A comparison of the relative efficiencies of the two sprays in controlling Scab is made dangerous by the lowness of yield, but it is evident, from the similarity of the percentage of Scab-free apples obtained from the Bordeaux and oil-Bordeaux plots, that both sprays are of the same order of fungicidal efficiency. This conclusion is based on the assumption that the biological factors affecting Scab infestation were similar in the two sprayed plots.

* There was no crop in the third control plot.

† It should be noted that in 1933 the total crop in this plot was only 142 apples.

In 1932 the greater Scab infection in the oil-Bordeaux plot was associated with smaller amounts of copper found to be retained on the foliage of the trees receiving this wash. The results of estimations in 1933 of the amounts of copper retained, expressed as milligrams of metallic copper per square metre of surface covered by the leaf, are given in Table II. The spray deposits given by the careful application of Bordeaux mixture and by the heavy application of the oil-Bordeaux emulsion are comparable in copper content and indeed it would appear that the amounts of copper retained on the foliage of the oil-Bordeaux plot are greater, after the lapse of one or two months, than those on the Bordeaux sprayed foliage. This improvement in retention is in agreement with previous observations* upon the relative retention of copper on potato foliage treated with Bordeaux and oil-Bordeaux sprays, and upon which was based the reduction of the amounts of copper sulphate and hydrated lime used in the oil-Bordeaux emulsion to half those employed in the Bordeaux mixture.

The 1933 results therefore confirm the opinion, based on the 1932 trial, that the avoidance of the formation of copper soaps by the use of a vegetable oil of low free fatty acid content would result in improved fungicidal efficiency of the oil-Bordeaux wash. Further they indicate that the incorporation of such an oil in Bordeaux mixture permits heavy application and reduction of copper concentration without loss of fungicidal efficiency.

TABLE II.

| | First post-blossom. Applied 23 May 1933. | | | | Second post-blossom. Applied 12 and 14 June 1933. | | | | |
|---|---|---|---|---|---|---|---|---|---|
| | Gals. per tree. | Man-minutes per tree. | mg.Cu./sq.m. leaf surface. 24/5 | 12/6 | Gals. per tree. | Man-minutes per tree. | mg.Cu./sq.m. leaf surface. 20/6 | 17/7 | 22/8 |
| Plot A. Bordeaux mixture: | | | | | | | | | |
| Newton Wonder .. | 1·8 | 3·0 | 103 | 95 | 2·25 | 3·8 | 209 | 131 | 74 |
| | | | 106 | 78 | | | 187 | 115 | 64 |
| Allington Pippin .. | | | 138 | 95 | | | 226 | 141 | 85 |
| | | | 88 | 99 | | | 230 | 149 | 74 |
| Plot B. Oil-Bordeaux: | | | | | | | | | |
| Newton Wonder .. | 4·5 | 3·9 | 117 | 99 | 3·7 | 3·7 | 225 | 170 | 131 |
| | | | 117 | 99 | | | 209 | 170 | 145 |
| Allington Pippin .. | | | 134 | 117 | | | 248 | 187 | 149 |
| | | | 115 | 127 | | | 269 | 187 | 131 |

In our article dealing with previous experiments (this *Journal*, No. 30, p. 61 (1932)) we reached the conclusion that under the conditions obtaining in the plantation at Wye College it might be profitable to give two pre-blossom applications of a fungicide to Newton Wonder instead of only one, as had been the practice in the years 1927-31. In the first year (1932) in which the additional pre-blossom application was made, a greater increase in percentage of Scab-free apples over the unsprayed crop was obtained, but as pointed out in our last article (this *Journal*, No. 32, p. 104 (1933)) this increase was not attributable to the effect of the extra early application, since the Scab fungus was not in evidence on the unsprayed trees until after the blossoming period. In 1933 the control of Scab was bad, being inferior even to that obtained, as a rule, in previous years

* Austin, M. D. and Martin, H.: in *Jour. S.E. Agric. Coll.*, No. 32, 49 (1933).

when only one pre-blossom application was given. It is clear that under the conditions in the College plantation the control of Scab is more difficult to obtain on Newton Wonder than on Allington Pippin. The question suggests itself—have we here a specialized form of the fungus on Newton Wonder? The possibility of the existence of " strains " with different powers of infection was first suggested by Wallace,* from circumstantial evidence. Recent investigations seem to show that a certain degree of specialization does exist in the parasitism of the Apple Scab fungus. Wiesmann,† working in Switzerland with pure cultures of the fungus, found that strains exist which differ in cultural characters, and he concluded that these represent different physiologic forms. In inoculation experiments made with conidia taken from the leaf it was found that the conidia from a given variety of apple were at least twice as virulent to the leaves of the same variety as to those of other varieties (secondary hosts). Palmiter,‡ working in the United States, with monoconidial cultures *in vitro*, found strains possessing distinctive powers of infection towards American commercial varieties of apple. Miss Johnstone,§ in this country, found evidence of the existence of biological strains capable of infecting certain varieties of apple only, and that a strain may exist on one variety of apple which is of special virulence. The assumption that the strain of the Apple Scab fungus on the Newton Wonders at Wye is a specialized form able to infect this variety more severely than the interplanted Allington Pippins would explain the differences in the incidence of infection met with during the past seven years, if the varietal susceptibility of Allington and Newton be taken as relatively constant.

## Summary.

1. Trees of Allington Pippin sprayed four times with home-made Bordeaux mixture, two applications pre-blossom and two post-blossom, gave 7·8 per cent of Scab-affected apples||; sprayed similarly with cotton-seed oil-Bordeaux emulsion, 7·2 per cent of Scab-affected apples.** In the three control (unsprayed) plots the percentages of Scab-affected apples were 81·9, 82·9 and 76·4.

2. Trees of Newton Wonder sprayed four times with home-made Bordeaux mixture gave 39·1 per cent of Scab-affected apples; sprayed similarly with cotton-seed oil-Bordeaux emulsion, 35·6 per cent of Scab-affected apples. In the two control (unsprayed) plots the percentages of Scab-affected apples were 91·4 and 93·4.

3. Cotton-seed oil-Bordeaux emulsion proved to be as fungicidal as ordinary Bordeaux mixture and to cause less injury (" russeting "). It is worthy of trial on an extended commercial scale, as it shows great promise, in that it can be applied speedily in a heavy wash, with which insecticides may be incorporated.

4. As in previous seasons, the attack of Apple Scab was far greater in the Newton Wonders than in the Allington Pippins. On the assumption that the varietal susceptibility of Allington Pippin and Newton Wonder is constant, the possibility of the existence of a specialized form of the fungus on the latter is suggested.

* Wallace, E.: " Scab Disease of Apples," *Cornell Univ. Agric. Exp. Stat.*, Bull. 335, pp. 580-1 (1913).

† Abstract in *Rev. Appl. Mycol.*, X, 464 (1931).

‡ *Phytopath.*, XXII, 21 (1932).

§ Johnstone, K. H.: " Observations on the Varietal Resistance of the Apple to Scab " (*Venturia inaequalis* Aderh.), with special reference to its physiological aspects (*Jour. Pomol.*, IX, pp. 43-45 (1931)).

|| Figures obtained from a crop of 56 lb. only.

** Figures obtained from a crop of 556 lb.

# SPRAYING EXPERIMENTS AGAINST PEAR SCAB

By H. MARTIN, E. S. SALMON and W. M. WARE.

THROUGH the kind co-operation of Mr. E. Vinson, Sandbanks Farm, Graveney, Kent, and as a result of his statement that Scab was almost uncontrollable on certain varieties of pear in a plantation on his farm, spraying experiments were undertaken in 1933.

The trees were upright cordons, of the varieties Louise Bonne of Jersey, Williams's Bon Chrétien, Marguérite Marillat and Doyenné du Comice, the varieties being planted in blocks in 1918, on the square, at approximately 5 ft. They were about 10 ft. high with a spread of 1-2 ft. The spray fluids used were Bordeaux mixture (8 lb. copper sulphate, 12 lb. hydrated lime, 100 gals. water) and cotton-seed oil-Bordeaux emulsion (4 lb. copper sulphate, 6 lb. hydrated lime, 6 pints Sudanese cotton-seed oil, 100 gals. water).

With each of these a comparison was made of the effects of two and of three post-blossom applications, all plots receiving one* pre-blossom spraying. The plots consisted of 1,240 trees of which 159 (composing three plots) were left unsprayed. Randomization of the plots was effected in such a way that the tests of spray fluids and of times of application were duplicated within the block of three of the four varieties, as follows :—

TABLE I.

| No. of Trees. | Variety. | Plots. | Treatments. |
|---|---|---|---|
| 97 | Louise Bonne. | A., H.1 | Bordeaux : one pre- and two post-blossom. |
| 104 | ,, | C., D. | Bordeaux : one pre- and three post-blossom. |
| 100 | ,, | E., I.1. | Oil-Bordeaux : one pre- and two post-blossom. |
| 91 | ,, | G.1., B. | Oil-Bordeaux : one pre- and three post-blossom. |
| 40 | ,, | F. | Not sprayed. |
| 432 | | | |
| 89 | Williams's. | H.2., L. | Bordeaux : one pre- and two post-blossom. |
| 105 | ,, | J., N.1. | Bordeaux : one pre- and three post-blossom. |
| 41 | ,, | M.1., I.2. | Oil-Bordeaux : one pre- and two post-blossom. |
| 52 | ,, | G.2., O.1. | Oil-Bordeaux : one pre- and three post-blossom. |
| 56 | ,, | K. | Not sprayed. |
| 343 | | | |
| 111 | Marguérite. | P., R. | Bordeaux : one pre- and two post-blossom. |
| 73 | ,, | N.2., U.1. | Bordeaux : one pre- and three post-blossom. |
| 96 | ,, | M.2., Q. | Oil-Bordeaux : one pre- and two post-blossom. |
| 72 | ,, | O.2., T.1. | Oil-Bordeaux : one pre- and three post-blossom. |
| 35 | ,, | S.1. | Not Sprayed. |
| 387 | | | |
| 22 | Comice. | U.2. | Bordeaux : one pre- and two post-blossom. |
| 28 | ,, | T.2. | Oil-Bordeaux : one pre- and two post-blossom. |
| 28 | ,, | S.2. | Not Sprayed. |
| 78 | | | |

* It had been intended to give two pre-blossom applications but the warm dry weather caused an early opening of the blossoms.

Power was provided by a new Drake & Fletcher " Mistifier " spraying machine with 4 h.p. Lister engine mounted, with a 3-throw pump, pressure chamber, and 100-gal. tank, on a horse-drawn chassis. This machine was left at some distance from the plantation, near the mixing tubs, and 39 overland steel pipes (each 15 ft.) extended from it to the far end of the plantation. To stop-cocks on the overland pipes, 4 rubber leads, each 120 ft., were fixed ; these made it possible to reach any tree in the plantation without having to move the central main. The four men spraying used short brass rods (only 2½ ft. long), each (except where specially noted) with tap and single nozzle on a brass bend. The pressure maintained on all occasions was 280-300 lb.

The first (pre-blossom) application was on 6 April under perfect conditions with warm sunshine and no wind. On account of the desire of the grower for speed in spraying and because men engaged on spraying work always seem inclined to move quickly only when great quantities of liquid are proceeding from the nozzle, No. 2 discs, very much worn and therefore with large aperture, were used. Partly on account of the speed of operations and also because of the complex arrangement of plots, one of these (H1, H2) which should have been sprayed with Bordeaux mixture (varieties Louise Bonne and Williams's) was missed.

Many trees of the variety Louise Bonne were without blossom, but the general stage of development was that in which the most advanced blossoms were showing white and nearly opening, the majority of flower buds having the petals still close-folded. Three or four leaves were unfolding on the blossom spurs. The wood buds were open and the rolled leaves were separating one from another.

The blossom trusses of the Williams's were not so separated and were in the " white " bud stage with very few leaves, and those close-rolled. The wood buds were not yet opened from the sharp-pointed condition. In the Marguérite Marillat, the trusses were in the white bud stage with some flowers opening. About six leaves were unrolling in each truss. The wood buds were opening and showing the points of the leaves but these were not yet unfolded. The Comice blossom buds were in all stages from closed to " white " bud, and four to five leaves on the flower truss were unrolling and flattening out. In the wood buds the leaves were now unrolling before opening.

All four varieties were examined on 6 April, before the first spraying, to determine whether the conidial (*Fusicladium*) stage of the Pear Scab fungus was already present on the young wood. As a result of the discovery made in 1932* that the youngest and often very short growth of the spurs might bear pustules in proximity to the blossom buds, special attention was paid to these parts.

Pustules were found on the young wood of Louise Bonne and the bark of older wood was very rough as a result of former plentiful infection. Active pustules were present on the young spur wood below the trusses, but owing to the scarcity of blossom no estimate could be made of the immediate danger. Although, in the Williams's, the one-year-old wood was healthy, pustules were found on the spur wood fairly commonly and one bud scale was noted with pustules embedded in its base. The variety Marguérite Marillat was bearing few young wood shoots and all the spurs, which were well provided with blossom buds, were healthy. Pustules were present on the young wood of Comice and, although not very numerous, they occurred sometimes in proximity to the wood buds now opening. A similar occurrence was found, though not commonly, on the spurs,

* Salmon, E. S. and Ware, W. M.: " Scab on the Spur Wood and Bud Scales of the Pear " (*Gard. Chron.*, XCI, No. 2372, 446-447, June 11, 1932).

close to the blossom buds. The bark of two-year-old wood was rough with the after-effects of Scab attack.

On 12 April all varieties were in full bloom as a result of the continued warm and dry weather, and the second (pre-blossom) spraying was therefore omitted. In the absence of blossom in the Louise Bonne, the trees were well covered with wood shoots or lambourdes, each rosette having four to five leaves fully expanded and two still rolled. The leaves and blossoms were healthy. The Williams's, on the other hand, were bearing an abundance of blossom but very little leaf. The trusses had one to three leaves among the blossoms and they were only in process of unrolling. Similarly the wood shoots and lambourdes were still in the rolled leaf state and it was noted that this variety was obviously one in which there would be very little leaf to spray at a time when the blossom is out. No Scab was found. A contrast in appearance was afforded by the Marguérite Marillat where, in an abundance of blossom, there was also abundant leaf production, each truss having about five leaves already unfolded. On the wood shoots about six leaves were unrolling or three were flattened and three still rolled. The time of blossoming of the Comice was somewhat later than in the other three varieties, the flowers being about to open or three of the six already open in the truss. On the other hand, the wood shoots were very leafy, four out of seven leaves in the rosette being unrolled and flattened in many cases. A scorching effect of the first spraying was visible on leaves of Marguérite Marillat only, in the form of two lines on either side of the midrib; it was just noticeable in the oil-Bordeaux plots and hardly noticeable in the Bordeaux plots. One-half of the plantation had been reserved by the owner for the usual sprayings and on 6 April had had an application of 1 : 20 lime-sulphur. Slight scorching of the foliage was visible on 12 April in all varieties and was rather more severe in Marguérite Marillat.

On 20 April, when the first post-blossom spray was applied, it was dull and cloudy, with a strong and cold wind from the NE. Early rain caused some delay in starting. Of the three men spraying, two were provided with new No. 1 discs in Drake & Fletcher nozzles and one with a double variable Noblox nozzle. The work was carried through expeditiously for the oil-Bordeaux plots (480 trees) for example were all finished in 32 minutes. In the non-experimental part of the plantation, all varieties (except Comice) were sprayed with lime-sulphur 1 : 40.

Immediately before the spraying, all varieties were examined. Some flowers in the Louise Bonne had not shed all their petals. Occasional fruitlets in the control plot were already infected by Scab on the calyx and receptacle and on the stalk. Scab was found on the petals in the plot (H1) which was not sprayed on 6 April. On the young wood, now 3 inches long, seven leaves were unrolled; in the lambourdes the rosette consisted of five leaves. Blossom had been so scarce in this variety that the relative incidence of Scab on the fruitlets could not be judged in the different plots. The foliage was, however, healthy everywhere. A flecking, in the form of minute black dots, occurred on the fruitlets in all plots including the control and in the lime-sulphur sprayed part of the plantation. It was attributed to the action of wind or hail. The Williams were just passing full bloom and petals were starting to fall. The new wood was only ¾-inch long, with six leaves unrolled. Lambourdes consisted of three to four leaves. The fruitlets were all healthy but slight black flecking occurred on the stalks. About three-quarters of the petals in the variety Marguérite Marillat had fallen. The young wood had reached a maximum growth of 2½ inches with seven leaves unrolled. Both leaves and fruitlets were everywhere healthy but black flecking injury was common on the fruitlets, both sprayed and unsprayed. The variety Comice was still in full bloom;

the new wood was 2 inches long, with four leaves and the lambourdes consisted of five leaves. The quantity of foliage in this variety was noticeable and was due in some measure to the presence of about six leaves in the blossom trusses. No Scab was found in any plot and the black flecking injury was rare.

Thirteen days later, on 3 May, the plantation was visited. A poor set of fruit in the Louise Bonne had resulted, there being hardly one in each truss of blossom. A few pears were infected with Scab on the sepals in all the plots sprayed with ordinary Bordeaux mixture and in the unsprayed but the foliage everywhere was healthy. Four of the eight leaves on the new wood showed spray deposit. No Scab was found in the oil-Bordeaux plots. Injury from the spraying occurred in the ordinary Bordeaux plots and took the form of slight spotting and scorch of the margins of the leaves; it was mostly on the windward side of the trees and was especially noticed at the exposed end of the plantation, in two plots which happened to have been sprayed with the double nozzle. In the oil-Bordeaux plots very little spray deposit was visible and no scorching had resulted. No injury was found in the part sprayed with lime-sulphur (1 : 20 pre-blossom and 1 : 40 post-blossom) which had received its post-blossom spraying on 24 April. In the control plot, where the new wood was about 6 inches long, with eight leaves, the foliage was healthy; a few of the fruitlets were infected.

In the Williams's, the longest new wood was 4 inches, with eight leaves. All the foliage was healthy and no spray damage had occurred except perhaps a slight black flecking of the stalks of the fruitlets which was absent in the unsprayed plot. Scab was established on a few of the fruitlets in the plots of both spray treatments as well as in the control plot, an indication that infection probably proceeded from pustules on the spur wood. The healthy state of the foliage showed that the course of infection was certainly not as it commonly is with the apple, where the fruit is very commonly infected after the fungus has established itself on the leaves near the blossom trusses. A bad set of fruit in the Williams's was evident, whole trusses failing and the blossoms falling. In the part sprayed with lime-sulphur there was no spray damage and no Scab infection. The variety Marguérite Marillat revealed itself as susceptible to injury, for in both ordinary and oil-Bordeaux treatments all the fruits were flecked with black marks and were blistered. The truss leaves also were covered with reddish spots and with brown, scorched marks. The new wood was 6 inches long, with nine leaves. No Scab occurred either on fruit or leaf. In the unsprayed plot, the foliage was healthy but a few pears were infected. Spray damage, attributed to drift, was present to a very small extent. In the lime-sulphur sprayed area, no leaf scorch or flecking of the fruit occurred. Ordinary Bordeaux mixture in the Comice had caused slight black scorching at the edges of the leaves and slight black flecking on the stalks of the fruits, all this damage being on the windward side of the trees. Oil-Bordeaux mixture, on the other hand, had produced little or no injury. The new wood growth was 4 inches long, with eight leaves. The fruit set was small in quantity. Scab was found on a few of the fruits in both spray treatments and in the control plot but the foliage was healthy. No scorching or injury was present in the unsprayed plot. In the lime-sulphur treatment of this variety, no Scab and no spray damage were found at this date.*

The second post-blossom spraying was carried out on 4 May under ideal conditions with sunshine and complete calm. The time taken, including washing out pipes between the use of the two fungicides, was 1 hour 25 minutes. For the ordinary Bordeaux

* Very severe russeting was, however, noted on all the lime-sulphur sprayed Comice fruits on 30 May, i.e. after the third application of lime-sulphur (1 in 50) on 4 May.

mixture one single Noblox nozzle, set to give a fine spray, and two single Drake & Fletcher nozzles with No. 0 discs were used by the three men. The Noblox nozzle provided sufficient volume of spray but at the fast speed at which the men were accustomed to work, the provision of No. 0 discs resulted in insufficient cover by the spray and the trees were not thoroughly done. For the oil-Bordeaux mixture, the same Noblox nozzle was used but No. 1 discs were fitted in the other two single nozzles ; this gave a better volume of spray but even so it was insufficient and the leaves were not made to drip, as desired.

On the same day the part of the plantation excluded from the experiment was sprayed with lime-sulphur at the strength of 1 in 50.

The plantation was next visited on 30 May and all the varieties were examined :— *Louise Bonne.*—In the plots sprayed with ordinary Bordeaux mixture, only three or four of the thirteen leaves on the new wood (now 10 inches long) showed a proper covering of spray deposit. Slight and occasional injury to the leaves was evident in the form of black spots or larger killed areas; more especially on leaves of lambourdes. The damage was often in two lines on either side of the midrib on the area touched by the spray when the leaf was rolled ; it was also present on the petioles. The foliage was entirely free from Scab. The fruits had taken on their red colour and were all healthy ; dark brown spots on the lowest part of the stalks were the only signs of russeting. In the plots sprayed with oil-Bordeaux mixture, both leaves and fruit were healthy, and damage, except in rare cases where a few leaves were spotted, was not found. The lime-sulphur sprayed trees of this variety showed no injury. In the control plot, no russeting or scorch was found and both foliage and fruit were healthy. *Williams's.*—The new wood growth was 12 inches long, with thirteen leaves. Spray damage in the ordinary Bordeaux mixture plots was negligible and was confined to slight brown spotting on a few of the lower leaves of the new wood, although on the foliage as a whole the spray deposit was not visible. The fruit here and there was russeted on the stalk and the skin was dull. Scab infection was noted on a few of the pears. The oil-Bordeaux mixture had caused no injury and Scab was absent except on a few pears on one outside tree. In the lime-sulphur sprayed area, no injury was found and the fruit was of excellent appearance with clear, shining red skin and no trace of russet on the stalk. In the unsprayed plot, about 25 per cent of the pears and a few of the leaves on each tree had become infected with large areas of Scab. *Marguérite Marillat.*—In the plots with both spray treatments, spray injury was evident at a glance. Five of the ten leaves on the new wood shoots (10 inches long) showed reddish purple spotting and the fruit was russeted and with dull skin. The leaves of lambourdes were spotted or scorched at the edges and the laminae were inrolled. There was no infection by Scab. The trees sprayed with lime-sulphur showed no injury and the fruit was of shining red colour with good skin finish. Here also there was no infection by Scab. In the unsprayed plot, 40-50 per cent of the pears were marked by large areas of Scab and a few leaves had recently become infected. On the new wood (15 inches) thirteen leaves were unrolled. *Comice.*—Similarly serious damage was evident in the plots sprayed with ordinary Bordeaux mixture but was hardly noticeable on the leaves in the oil-Bordeaux mixture plots. Both sprays, however, had caused a brown russeting on the skin of the green pears. In the plots sprayed with ordinary Bordeaux mixture, five of the twelve leaves on the young wood shoots (15 inches) had evidently been sprayed for they were black-spotted and badly curled. No Scab was found in any plot of either treatment. The lime-sulphur spraying had caused slight injury at the margins of a few leaves and the fruit was as badly russeted as in the Bordeaux-sprayed plots. No Scab was found on foliage or fruit but the set of pears was particularly poor. In the unsprayed plot, the pears

were green and smooth with no trace of russeting ; here and there a single area of infection by Scab occurred on the fruit. The strongest attack yet seen on the foliage was found in this variety. Infection of the upper surface of the leaves was starting, while it was in a more advanced state on the lower surface. On many of the young wood

Fig. 1. Young shoot of pear, Doyenné du Comice, from the unsprayed (control) plot, showing Scab on both leaves and stem. Photographed 30 May 1933. Natural size.

shoots the fungus was particularly well established, forming velvety patches on the bark on which conidia were being produced (Fig. 1).

The third post-blossom spraying was on 1 June when once again ideal conditions of weather prevailed. On this occasion, with fewer plots to be sprayed, only two men were employed ; they used short metal rods (3 ft. long) with single nozzles fitted with

new No. 0 discs for the ordinary Bordeaux mixture and with No. 1 discs for the oil-Bordeaux mixture. In the part of the plantation excluded from the experiment, lime-sulphur (1 in 50) was again applied.

A final visit to the plantation was paid on 12 August and notes were again made on the condition of the trees. *Louise Bonne*.—In the ordinary Bordeaux mixture plots, signs of injury in the form of small spots were still visible on the leaves. The fruit was too scarce to judge the relative intensity of Scab attack but it was estimated that about 25 per cent of the pears were infected in Plot H1. No russeting of the fruit was found. In the oil-Bordeaux plots, the foliage was healthy and without injury ; the fruit on the other hand was infected to the extent of 40-50 per cent* with small or large corky Scab-spots, but spray injury was absent. In the lime-sulphur sprayed trees, the foliage was healthy but about 10 per cent of the pears were infected with Scab. In the control plot, the foliage was healthy but most of the fruit was infected with old and dry, corky, Scab areas, sometimes in one large patch covering half the surface of the pear. *Williams's*.—The trees had been summer-pruned or were in process of being pruned. In the ordinary Bordeaux plots the foliage was healthy but in the plots which received three post-blossom applications a trace of injury was visible. About 40 per cent of the fruit on trees sprayed twice post-blossom were infected and about 10 per cent on the trees sprayed three times post-blossom. In the oil-Bordeaux plots the leaves were healthy ; about 30 per cent of the fruit on trees sprayed twice post-blossom were infected and about 10 per cent on the trees sprayed three times post-blossom. No injury was apparent on leaves or fruit. In the lime-sulphur sprayed area, both leaves and fruit were healthy though it was estimated that about 5 per cent of the fruit were slightly infected. In the control plot, the leaves remaining after pruning were healthy but about 60 per cent of the fruit were infected with large, corky, Scab areas. *Marguérite Marillat*.—In the ordinary Bordeaux mixture plots, a trace of spray injury was visible on the leaves remaining after summer-pruning, these being curled and spotted with black discoloration. Scab on the foliage was found only rarely, but since only about six leaves remained on the young wood shoots after pruning, it was impossible to judge whether any late attacks had occurred. The fruit was of good appearance and about 95 per cent were healthy in the case of plots with both two and three post-blossom treatments. In the oil-Bordeaux plots both foliage and fruit were healthy, it being estimated that only about 5 per cent of the pears were infected with Scab. No spray injury was observed. The trees sprayed with lime-sulphur were very healthy, no Scab being found on the fruit and only a few infected leaves here and there. No damage had resulted. In the control plot about 60 per cent of the large, heavy, green fruits were infected and the leaves remaining after pruning were commonly spotted with Scab on both upper and lower surfaces of the laminae. *Comice*.—Ordinary Bordeaux mixture (twice post-blossom) had resulted in about 90 per cent of the fruit being healthy. The spray injury to the foliage already noted was still present but was partly hidden by the growth of newer leaves. Oil-Bordeaux mixture had given equally good results with 90 per cent of the fruit healthy. Summer-pruning had not been done in this variety and in the oil-Bordeaux plot Scab was occasionally present on the foliage and stems of the new wood shoots, the longest of which had reached a length of 4 feet. The lime-sulphur sprayed trees were fairly healthy, about 80 per cent of the fruit being free from Scab ; occasional infected leaves were, however, found. In the control plot, all of the pears were infected and all of the leaves on the new wood shoots, although not very severely.

* As will be seen later, the fruit of Louise Bonne and of Comice was not graded for scab-infection. The percentages quoted, although rough estimations, are probably to be relied upon, as reference to Table II will show for Williams's and Marguérite Marillat.

TABLE II.

| Plot. | Treatment. | Marguérite Marillat. Weight (lb.) Clean. | Scabbed. | Per cent Scabbed. | Total. | Number. Clean. | Scabbed. | Per cent Scabbed. | Total. | Williams's Bon Chrétien. Weight (lb.) Clean. | Scabbed. | Per cent Scabbed. | Total. | Number. Clean. | Scabbed. | Per cent Scabbed. | Total. | Plot. |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| S.1. | Unsprayed .. | 33·5 | 133·5 | 80·0 | 167·0 | 70 | 269 | 79·4 | 339 | 32·5 | 117·0 | 78·3 | 149·5 | 108 | 410 | 79·2 | 518 | K. |
| R. | Bordeaux mixture: one pre- and two post-blossom applications | 99·0 | 4·0 | 3·9 | 103·0 | 172 | 6 | 3·4 | 178 | 30·5 | 29·5 | 49·2 | 60·0 | 90 | 87 | 49·1 | 177 | B.2. |
| P. | | 146·0 | 18·0 | 11·0 | 164·0 | 246 | 28 | 10·2 | 274 | 94·5 | 57·5 | 37·8 | 152·0 | 286 | 176 | 38·1 | 462 | L. |
| N.2. | Bordeaux mixture: one pre- and three post-blossom applications. | 73·5 | 1·5 | 2·0 | 75·0 | 138 | 2 | 1·4 | 140 | 149·0 | 16·0 | 9·7 | 165·0 | 478 | 46 | 8·8 | 524 | J. |
| U.1. | | 165·0 | 9·0 | 5·2 | 174·0 | 309 | 17 | 5·2 | 326 | 124·0 | 23·0 | 15·6 | 147·0 | 350 | 62 | 15·1 | 412 | N.1. |
| M.2. | Bordeaux emulsion: one pre- and two post-blossom applications. | 165·5 | 10·0 | 5·7 | 175·5 | 321 | 23 | 6·7 | 344 | 28·0 | 24·5 | 46·7 | 52·5 | 86 | 74 | 46·2 | 160 | I.2. |
| Q. | | 96·5 | 4·0 | 4·0 | 100·5 | 150 | 6 | 3·8 | 156 | 67·5 | 12·5 | 15·6 | 80·0 | 207 | 36 | 14·8 | 243 | M.1. |
| O.2. | Bordeaux emulsion: one pre- and three post-blossom applications. | 133·5 | 1·5 | 1·1 | 135·0 | 285 | 5 | 1·7 | 290 | 59·0 | 3·5 | 5·6 | 62·5 | 182 | 11 | 5·7 | 193 | G.2. |
| T.1. | | 159·5 | 5·0 | 3·0 | 164·5 | 275 | 8 | 2·8 | 283 | 128·0 | 19·0 | 12·9 | 147·0 | 428 | 65 | 13·2 | 493 | O.1. |

On 23 August, when the crop was picked, it was found that the quantity of pears in the varieties Louise Bonne and Comice was insufficient to provide data, and they were therefore not graded. The crop of fruit, however, in the varieties Marguérite Marillat and Williams's was satisfactory and each plot was picked separately, the fruit from the one outer (" guard ") row on all sides of each plot being disregarded.

Owing to the size and conspicuous nature of the Scab areas on the fruit, it was decided to establish only two grades, viz. healthy and infected. The fruit after being placed in these two grades was counted and weighed, the results being shown in the following Table II.

A statistical analysis of the results of percentage number of scabbed fruit picked per plot is given in Table III.

TABLE III.

| | Sum of squares of deviations. | Degrees of Freedom. | Variance $\sigma^2$ | $\frac{1}{2}\log_e\sigma^2$ | " Z." |
|---|---|---|---|---|---|
| Variety (V) .. .. | 1517·1000 | 1 | 1517·10 | 3·6622 | 1·4738 |
| Sprays (S) .. .. .. | 82·8125 | 1 | 82·81 | 2·2082 | — |
| Number of Applications (N) | 876·1625 | 1 | 876·16 | 3·3878 | 1·1994 |
| Interactions : | | | | | |
| V × S .. .. .. | 42·8475 | 1 | 42·85 | 1·8789 | — |
| V × N .. .. .. | 533·6075 | 1 | 533·61 | 3·1398 | 0·9514 |
| S × N .. .. .. | 30·8000 | 1 | 30·80 | 1·7137 | — |
| V × S × N .. .. | 24·9100 | 1 | 24·91 | 1·6076 | — |
| Error .. .. .. | 636·6000 | 8 | 79·58 | 2·1884 | — |
| | 3744·8400 | 15 | | | |

The value of " z " appropriate for P = 0·05 is 0·8355 and it may therefore be concluded that :—

1. No difference is shown in the degree of Scab control given by the Bordeaux mixture and the oil-Bordeaux emulsion.

2. A better control of Scab has been obtained on the variety Marguérite Marillat than on the variety Williams's Bon Chrétien :—

   Mean percentage scabbed fruit :—

   on Marguérite Marillat = 4·4
   on Williams's Bon Chrétien = 23·875 } Significant difference = 9·57%

3. Three post-blossom applications of the sprays has given a better control of Scab than two post-blossom applications :—

   Mean percentage scabbed fruit :—

   2 post-blossom = 21·537
   3 post-blossom = 6·737 } Significant difference = 9·57%

4. The improvement in Scab control resulting from three post-blossom applications is greater on the variety Williams's Bon Chrétien than on the variety Marguérite Marillat.

At the time of grading, it was noticed that the Marguérite Marillat pears which had been sprayed with the oil-Bordeaux mixture (Plots T1, O2, Q, M2) had clean, smooth skins while those sprayed with ordinary Bordeaux mixture were distinctly rougher in Plots N2, P, U1. On the other hand, in Plot R, a duplicate of P, the roughness of the skin was only slight and the " finish " nearly as good as in the oil-Bordeaux plots. The Marguérite were large pears some of which weighed as much as 1½ lb.

The " finish " and smoothness of skin in the Williams's was everywhere excellent except in one plot (H2) which received only two post-blossom sprayings with ordinary Bordeaux mixture. It was this plot which was by accident missed on the occasion of the one pre-blossom application.

SUMMARY.

1. An account is given of a spraying experiment to control Scab in four varieties of pear, viz. Louise Bonne, Williams's Bon Chrétien, Marguérite Marillat and Doyenné du Comice by means of hydrated lime Bordeaux mixture and cotton-seed oil-Bordeaux emulsion.

2. The crops of Louise Bonne and of Doyenné du Comice were insufficient to be worth grading for Scab but in Marguérite Marillat the weight in all plots was 11 cwt. 26½ lb. and in Williams's Bon Chrétien, 9 cwt. 7½ lb. No appreciable "russeting " to the fruit of the Williams's was caused by either spray fluid, but a slight roughness of the skin in the variety Marguérite Marillat resulted from the use of the Bordeaux mixture.

3. Trees of Marguérite Marillat sprayed with Bordeaux mixture, one pre- and two post-blossom applications, gave 3·4 per cent and 10·2 per cent of Scab-affected pears in the two plots, and with one pre- and three post-blossom applications, 1·4 per cent and 5·2 per cent in the two plots ; sprayed with cotton-seed oil-Bordeaux emulsion, one pre- and two post-blossom applications, 6·7 per cent and 3·8 per cent in the two plots, and with one pre- and three post-blossom applications, 1·7 per cent and 2·8 per cent in the two plots. In the one control (unsprayed) plot the percentage of Scab-affected pears was 79·4.

4. Trees of Williams's Bon Chrétien sprayed with Bordeaux mixture, one pre- and two post-blossom applications, gave 49·1 per cent and 38·1 per cent of Scab-affected pears in the two plots, and with one pre- and three post-blossom applications, 8·8 per cent and 15·1 per cent in the two plots ; sprayed with cotton-seed oil-Bordeaux emulsion, one pre- and two post-blossom applications, 46·2 per cent and 14·8 per cent in the two plots, and with one pre- and three post-blossom applications, 5·7 per cent and 13·2 per cent. In the one control (unsprayed) plot the percentage of Scab-affected pears was 79·2 per cent.

5. In the above-named varieties cotton-seed oil-Bordeaux emulsion appeared to be as good a fungicide as ordinary Bordeaux mixture, and three post-blossom applications of either fungicide gave a better control of Scab than two.

6. Both Bordeaux mixture and the Bordeaux emulsion caused damage to the foliage of the varieties Marguérite Marillat and Doyenné du Comice.

7. The Pear Scab fungus in its conidial (*Fusicladium*) stage was found, often in abundance, on the young wood of the varieties Louise Bonne and Doyenné du Comice (young wood and spurs) and Williams's Bon Chrétien (young wood, spurs and one bud-scale).

# SOIL PROFILES DEVELOPED ON CARBONIFEROUS LIMESTONE IN SOMERSET AND DERBYSHIRE

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In Somerset and Derbyshire there are large outcrops of Carboniferous Limestone, and each forms part of an anticline. The fairly flat upland country of the Somerset region is the Mendip Hills and rises to 1,000 feet. Derbyshire is more hilly than the Mendips with greater altitudes. Both areas are sparsely inhabited, most of the land being pasture, with a few small woods here and there with rather more in Somerset.

The climate of the two regions cannot be compared satisfactorily owing to the absence of data. There is, however, little difference in rainfall (see Table III), but to what extent the temperatures differ, it is not possible to ascertain with accuracy owing to the absence of any stations on the Mendips. But it is probably true to say that the average temperature of the Derbyshire hills is lower than that of the Mendips.*

The Carboniferous Limestone is a greyish-blue rock in the regions studied, and the beds are characteristically jointed. The jointing leads to a very free natural drainage, and there are practically no surface streams in either region. The hills are honeycombed with underground water courses, and occasionally the overlying rock falls into these underground tunnels helping to produce great gorges such as Cheddar in the Mendips. The soil drainage is, of course, excessive, so that grass and other vegetation suffer greatly in time of drought as there is little or no upward movement of water. The jointing also leads to great variation in the depth of the soil. Within a few square yards, it may vary in depth from 12 inches or less to 48 inches or more.

To-day, there is very little land under the plough in either of the regions studied, whereas formerly there were considerable areas, particularly in Somerset. Consequently the upper horizons of a number of the soils examined have been disturbed by cultivation so as to destroy the profile developed under conditions in which man had played no part. In the field studies in both regions, positions have been chosen where the soils formed are sedentary.

## THE SOILS DEVELOPED ON THE CARBONIFEROUS LIMESTONE OF THE MENDIPS.

Soils developed on Carboniferous Limestone (and, as far as can be ascertained, free from colluvial material) have been placed in three series: the Mendip, Menpod and Menwood, the first being developed under grass, the second and third in woods. The Mendip series is by far the most widely distributed, the greater part of the Carboniferous Limestone outcrop of the Mendips being under grass.

* From a map of the British Isles showing annual temperatures, the average temperature of the Derbyshire region is 42°–44°F. whilst for the Somerset region 48°–50°.

MENDIP SERIES.

The descriptions of the Mendip series show that it has a simple profile consisting of a light brown to reddish-brown loam in the upper horizons, becoming usually a red silt loam in the lower horizons. The colour of the lower horizon is sometimes yellowish-brown, and this seems to be associated with a less excessive drainage. Wherever the soil is ploughed, the colour of the surface is a very reddish-brown, and even when the land is under bracken, the upper horizon is frequently very reddish in colour. On some slopes where the soil is shallow, the red is remarkably bright. This is probably because the soil is eroded, and the brighter coloured lower horizons are exposed. The drainage of this series is not only free but excessive. The complete leaching of the carbonates is to be noted, and the slight acidity of the upper horizons in most members of the series. The lower horizons are neutral to alkaline. There is an increase in heaviness of texture from the surface downwards, the uppermost horizon is usually loam to silty loam. As the parent material is reached, one passes through silt loam to silty clay loam and even to clay loam in some cases.

MENWOOD SERIES.

The Mendip series is probably not the natural soil of the Carboniferous Limestone of the Mendip Hills. Originally, these hills were covered with forest (Billingsley, J., 1797. General View of the Agriculture of the County of Somerset with observations on the means of its improvement), but owing to the mining of lead and other ores, these primitive forests have been removed. To-day, there are a few small woods, some being of deciduous trees, others of conifers. The Menwood series is typically developed on deciduous woodland ; the soils under conifers are frequently the same, but where this is so the conifers seem to have been planted during the last half century or so. This series is distinguished from the Mendip by the greyish-brown surface horizon which is covered with forest litter. Below this there is a brown horizon which becomes reddish-brown before the parent material is reached. In a beech wood, No. 238S is developed, and there is some carbonate accumulation in the first few inches. This may be due to leaf-fall restoring to the surface some of the leached calcium carbonate.

MENPOD SERIES.

It has already been pointed out that the coniferous woods in which the Menwood series is developed are comparatively young. In an old-established wood where it seems quite certain that the soils are sedentary on Carboniferous Limestone good examples of podsolization are found. The first 8 inches are greyish-brown, and acid in reaction at the surface ; below this is a horizon, 1 to 2 inches in depth, of rusty-brown iron-stained silt loam. This is followed by a sharp change, to quite a hard compact horizon, although there is not a great textural change. The change is felt very definitely with the auger. Below this the profile has the usual characteristics of the Menwood series. No carbonates were found, until the parent material was reached. There appear to be few examples of this Series on the Mendips.

MEN AND PEN SERIES PROFILES.

Neither of these profiles is developed in a sedentary soil on Carboniferous Limestone, but both contain colluvial material from the Old Red Sandstone outcrops of the Mendips. They are included in the present paper because they are found on the Carboniferous Limestone.

### Position of the Soils Developed on Carboniferous Limestone in the Mendips in the International Soil Classification.

These red soils of the Mendips resemble the Terra Rossa of Southern France which the author has examined, one of the chief differences being that the colours in the Mendips are not as bright as those of Southern France. The red soils of the Mendips, then, may represent a northerly occurrence of the Terra Rossa, a soil developed in a climate warmer than that of south-west England. It is an intrazonal soil, and as the parent material is a dominant factor in the soil formation, it is an Endodynamomorphic soil.

## THE SOILS DEVELOPED ON THE CARBONIFEROUS LIMESTONE OF DERBYSHIRE.

A general examination of the soils on the Carboniferous Limestone in Derbyshire has led to the identification of three series : the Buxton, Hurdlow and Wheeldon. The object of this study was to make a comparison with soils on the corresponding formation on the Mendips, and positions for the examination of the profile were again chosen where there would be little or no colluvial material either of Carboniferous Limestone or of any other rocks.

### Wheeldon Series.

The description of this profile is very simple—a black silt loam with a maximum depth of 6 inches. It passes without change to the parent material. It has only been found at high altitudes above 1,200 feet, the example given being found at 1,350 feet. Owing to the shallowness of the soil and the exposed position, fragments of broken limestone were found scattered through the profile and probably account for the carbonate value and the neutral reaction.

### Buxton Series.

This is a greyish-brown silt loam in the upper horizons becoming more brown as we descend. The texture increases from a silt loam at the surface to a silty clay loam in the lower horizon. There is almost complete leaching of carbonates and the reaction of the upper horizons is neutral to slightly acid, the lower being neutral to alkaline. It seems fairly widely distributed on the upland pastures of the Derbyshire Carboniferous Limestone.

### Hurdlow Series.

This also is a greyish-brown silt loam in the upper horizons, becoming more brown as we descend, but in the lower horizons a reddish colour is found ; this has not been observed in the other series in Derbyshire. There is complete leaching of carbonates and the reaction is slightly acid in the upper horizons, the lower being neutral. This series resembles closely the Menwood, and an examination of the profile descriptions of 10D and 238S illustrates this. The chief difference is that the Hurdlow occurs under grass whereas the Menwood is found in woods.

POSITION OF THE SOILS DEVELOPED ON CARBONIFEROUS LIMESTONE IN DERBYSHIRE IN THE INTERNATIONAL SOIL CLASSIFICATION.

The field examination of these soils places the Hurdlow and Buxton series in the Brown Earth group of Ramann's classification. Parent material is an important factor, so that they also fall into the Endodynamomorphic group of Glinka. They are also intrazonal soils. The black peaty material of the Wheeldon series is probably due more to low temperature than the presence of calcium carbonate, but further examination is necessary to decide this question.

## COMPARISON OF THE SOILS DEVELOPED ON CARBONIFEROUS LIMESTONE IN DERBYSHIRE AND THE MENDIPS.

The climatic conditions in Derbyshire are somewhat different from those in the Mendips, so we might expect to find some slight differences in the profile, but only slight because the climatic differences are not great. The altitudes of the soils in the two regions studied are also different, and this would tend to make the climatic differences greater. (In Derbyshire the average altitude of the profiles studied is 1,200 feet and in the Mendips 800 feet.) We find that the Mendip soils resemble the Terra Rossa, whereas in Derbyshire they are fairly good examples of the Brown Earths. With the colder climate of Derbyshire, the chemical changes, resulting in the formation of the ferric compounds which give the red colour to the limestone soils of the Mendips, do not proceed to the same extent, and the brown colours predominate.

### PROFILE DESCRIPTIONS.

232S.—MENDIP SERIES.

Geology: Carboniferous Limestone.
Origin: Sedentary.
Colour: Light brown.
Topography: Flat.
Drainage: Good—excessive.
Profile:—

No $CO_2$ evolved with hydrochloric acid 0-18″. Light brown loam to silty loam.

No $CO_2$ evolved with hydrochloric acid 18-24″. Reddish-brown silty loam to silt loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 24″. Broken limestone.

The depth at which rock occurs varies. The ground is covered with bracken and gorse.

241S.—MENDIP SERIES.

Geology: Carboniferous Limestone.
Origin: Sedentary.
Colour: Chocolate-brown.
Topography: Flat.
Drainage: Good—excessive.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-3″. Chocolate-brown silty loam.

No $CO_2$ evolved with hydrochloric acid 3-8″. Lighter brown silt loam.

No $CO_2$ evolved with hydrochloric acid 8-14″. Reddish-brown silt loam to silty clay loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 14″. Broken limestone.

The depth of the profile varies. Pasture.

242S.—MENDIP SERIES.

Geology : Carboniferous Limestone.

Origin : Sedentary.

Colour : Reddish-brown.

Topography : Fair slope to NW.

Drainage : Good—excessive.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-3″. Reddish-brown silty loam.

No $CO_2$ evolved with hydrochloric acid 3-17″. Brownish-red to bright red silt loam.

No $CO_2$ evolved with hydrochloric acid 17-21″. Deep red silty clay loam—with slight purplish tint near rock.

Vigorous evolution of $CO_2$ with hydrochloric acid 21″. Broken limestone.

Depth varies. This profile is subjected to more erosion than the examples of the Mendip series already given, so that the darker coloured upper horizons do not become as deep as in examples 232S and 241S. Vegetation—grass.

238S.—MENWOOD SERIES.

Geology : Carboniferous Limestone.

Origin : Sedentary.

Colour : Black.

Topography : Flat—at the top of a hill.

Drainage : Good—excessive.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-1″. Forest litter.

Some $CO_2$ evolved with hydrochloric acid 1-8″. Dark brown to greyish-brown silt loam.

Very little $CO_2$ evolved with hydrochloric acid 8-14″. Light brown with reddish tint silt loam to silty clay loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 14″. Limestone.

Vegetation—beech wood.

251S.—MENPOD SERIES.

Geology : Carboniferous Limestone.

Origin : Sedentary.

Colour : Greyish-brown.

Topography : Flat.

Drainage : Good.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-10″. Dark grey to greyish-brown silty loam.

No $CO_2$ evolved with hydrochloric acid 10-11½″. Rusty-brown iron stained silt loam.

No $CO_2$ evolved with hydrochloric acid 11½-30″. Light brown silt loam to silty clay loam more compact than 0-11½″.

No $CO_2$ evolved with hydrochloric acid 30-36″. Reddish-brown to red clay loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 36″. Limestone.

This soil developed under woodland conditions—trees recently felled.

227S.—Men Series.

Geology : Carboniferous Limestone.

Deposition : Sedentary, possibly some colluvial from Old Red Sandstone of Pen Hill.

Colour : Dark greyish-brown.

Topography : Flat.

Drainage : Good.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-3″. Forest litter—pine needles, etc.

No $CO_2$ evolved with hydrochloric acid 3-6″. Greyish silt loam which is bleached in appearance.

No $CO_2$ evolved with hydrochloric acid 6-20″. Reddish-brown silt loam with small particles of stones—not carbonates—appear siliceous. Texture becomes silty clay loam and more reddish at 18″ with a few black particles.

No $CO_2$ evolved with hydrochloric acid 20-24″. Brownish-red silty clay loam—very few black particles.

Vigorous evolution of $CO_2$ with hydrochloric acid 24″. Broken limestone mixed with red silty clay loam.

Vegetation—Pines.

230S.—Pen Series.

Geology : Carboniferous Limestone.

Deposition : Sedentary, and probably colluvial Old Red Sandstone.

Colour : Dark greyish-brown.

Topography : Very slight slope to South.

Drainage : Fairly good.

Profile :—

No $CO_2$ evolved with hydrochloric acid 0-8″. Dark greyish-brown fine sandy loam.

No $CO_2$ evolved with hydrochloric acid 8-20″. Yellowish almost bleached fine sandy loam—many small white stones—not carbonates.

No $CO_2$ evolved with hydrochloric acid 20-54″. Reddish-brown silt loam—many stones as in 8-20″ becoming silty clay loam with many black particles. Colour becomes brownish-red. Vegetation—grass.

6D.—WHEELDON SERIES.

Geology : Carboniferous Limestone.
Origin : Sedentary.
Colour : Black.
Topography : Top of a hill 1,350′.
Drainage : Good.
Profile :—

Some $CO_2$ evolved with hydrochloric acid 0-6″. Black silt loam—depth varies, 6″ is the maximum.

Vigorous evolution of $CO_2$ with hydrochloric acid 6″. Broken limestone.

Vegetation—grass.

10D.—HURDLOW SERIES.

Geology : Carboniferous Limestone.
Origin : Sedentary.
Colour : Greyish-brown.
Topography : Slight slope towards East.
Drainage : Good.
Profile :—

No $CO_2$ evolved with hydrochloric acid 0-3″. Greyish-brown silt loam.

No $CO_2$ evolved with hydrochloric acid 3-9″. Brown silt loam becoming lighter brown silt loam.

No $CO_2$ evolved with hydrochloric acid 9-20″. Reddish-brown silt loam to silty clay loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 20″. Limestone.

Vegetation—grass.

7D.—BUXTON SERIES.

Geology : Carboniferous Limestone.
Origin : Sedentary.
Colour : Greyish-brown.
Topography : Flat.
Drainage : Good.
Profile :—

No $CO_2$ evolved with hydrochloric acid 0-7″. Greyish-brown silt loam becoming more brown with depth.

No $CO_2$ evolved with hydrochloric acid 7-22″. Light brown passing into cinnamon-brown silty clay loam.

Vigorous evolution of $CO_2$ with hydrochloric acid 22″. Broken limestone.

Vegetation—grass.

TABLE I.

*Amounts of Carbonates expressed as percentage $CaCO_3$.*

| | $\% CaCO_3$. |
|---|---|
| Mendip Series, No. 232S. | |
| 0-8″ | 0 |
| 8-18″ | 0 |
| 18-24″ | 0 |
| Mendip Series, No. 233S. | |
| 0-3″ | 0 |
| 3-11″ | 0 |

TABLE I.—*Continued.*

| | $\%CaCO_3$. |
|---|---|
| Mendip Series, No. 241S. | |
| 0–3″ | 0 |
| 3–8″ | 0 |
| 8–14″ | 0 |
| Mendip Series, No. 242S. | |
| 0–3″ | 0 |
| 3–17″ | 0 |
| 17–21″ | 0 |
| Mendip Series, No. 231S. | |
| 0–8″ | ·04 |
| 8–18″ | ·01 |
| 18–26″ | ·002 |
| 26–34″ | ·007 |
| No. 239S—adjoins beech wood of No. 238S—probably a soil of Menwood Series changing to Mendip Series. | |
| 0–6″ | 1·34 |
| 6–12″ | 3·34 |
| 12–18″ | 4·34 |
| Menwood Series, No. 238S. | |
| 0–½″ | ·104 |
| ½–8″ | 2·167 |
| 8–14″ | ·63 |
| Menwood Series, No. 226S. | |
| 0–14″ | 0·88 |
| 14–34″ | 0·07 |
| 34–36″ | 26·69 (contains powdered limestone fragments). |
| Men Series, No. 227S. | |
| 0–3″ | ·14 |
| 3–5½″ | ·01 |
| 5½–15″ | 0 |
| 15–24″ | ·02 |
| 24″ | 8·4 |
| Pen Series, No. 230S. | |
| 0–8″ | ·008 |
| 8–20″ | ·004 |
| 20–54″ | 0 |
| Wheeldon Series, 6D. | |
| 0–6″ | 0·36 |
| Buxton Series, 7D. | |
| 0–7″ | 0 |
| 7–22″ | 0 |
| Buxton Series, 9D. | |
| 0–4″ | ·21 |
| 4–12″ | 0 |
| 12–17″ | 0 |
| Hurdlow Series, 8D. | |
| 0–1″ | 0 |
| 1–12″ | 0 |
| 12–18″ | 0 |
| Hurdlow Series, 10D. | |
| 0–3″ | 0 |
| 3–9″ | 0 |
| 9–20″ | 0 |

## TABLE II.

*Approximate pH values (determined colorimetrically).*

233S—Mendip Series.

| | pH. |
|---|---|
| 1" | 6·5–7·0 |
| 8" | 6·5–7·0 |
| 11" | 7·0–8·0 |

232S—Mendip Series.

| | pH. |
|---|---|
| 1" | 6·0 |
| 8" | 6·0–7·0 |
| 16" | 6·5–7·0 |
| 24" | 7·0 |

231S—Mendip Series.

| | pH. |
|---|---|
| 1" | 6·5–7·0 |
| 8" | 7·0 |
| 16" | 7·0 |
| 28" | 7·0–8·0 |

241S—Mendip Series.

| | pH. |
|---|---|
| 1" | 6·0–7·0 |
| 8" | 7·0 |
| 16" | 7·0 |
| 24" | 7·0–8·0 |

242S—Mendip Series.

| | pH. |
|---|---|
| 0–3" | 6·0 |
| 3–17" | 6·5–7·0 |
| 17–21" | 7·0 |

239S.

| | pH. |
|---|---|
| 0–6" | 7·0 |
| 6–12" | 7·0–8·0 |
| 12–18" | 7·0–8·0 |

238S—Menwood Series.

| | pH. |
|---|---|
| 0–½" | 6·5–7·0 |
| ½–8" | 7·0 |
| 8–14" | 7·0 |

226S—Menwood Series.

| | pH. |
|---|---|
| 0–14" | 7·0 |
| 14–34" | 7·0 |
| 34–36" | 7·0–8·0 |

249S—Menwood Series, Deep Phase.

| | pH. |
|---|---|
| 1" | 6·0–7·0 |
| 8" | 7·0 |
| 18" | 7·0–8·0 |
| 36" | 7·0–8·0 |
| 54" | 7·0 |

TABLE II.—*Continued.*

248S—Menwood Series, Deep Phase.

| | pH. |
|---|---|
| 1" | 6·0 |
| 8" | 7·0 |
| 16" | 7·0 |
| 36" | 6·5–7·0 |
| 54" | 6·5–7·0 |

250S—Menwood Series, Deep Phase.

| | pH. |
|---|---|
| 1" | 6·0 |
| 8" | 7·0 |
| 18" | 7·0 |
| 36" | 7·0–8·0 |
| 54" | 7·0–8·0 |

251S—Menpod Series.

| | pH. |
|---|---|
| 1" | 6·0 |
| 8" | 6·0–7·0 |
| 18" | 7·0 |
| 36" | 7·0–8·0 |

230S—Pen Series.

| | pH. |
|---|---|
| 0–8" | 7·0 |
| 8–20" | 7·0 |
| 20–54" | 7·0 |

227S—Men Series.

| | pH. |
|---|---|
| 0–3" | 6·0 |
| 3–5½" | 6·0 |
| 5½–15" | 6·0 |
| 15–24" | 6·0 |
| 24" | 7·0 |

6D—Wheeldon Series.

| | pH. |
|---|---|
| 0–6" | 7·0 |

9D—Buxton Series.

| | pH. |
|---|---|
| 0–4" | 6·5–7·0 |
| 4–12" | 6·5–7·0 |
| 12–17" | 7·0 |

7D—Buxton Series.

| | pH. |
|---|---|
| 0–7" | 7·0 |
| 7–22" | 7·0 |
| 22" | 7·0–8·0 |

8D—Hurdlow Series.

| | pH. |
|---|---|
| 0–1" | 6·0 |
| 1–12" | 6·5–7·0 |
| 12–18" | 6·5–7·0 |

10D—Hurdlow Series.

| | pH. |
|---|---|
| 0–3" | 6·5–7·0 |
| 3–9" | 6·5–7·0 |
| 9–20" | 7·0 |

TABLE III.

Normals of Monthly Rainfall, 1881–1915 (Air Ministry). Derby, Buxton (Devonshire Hospital), 53° 16′ N. 1° 55′ W. 987 ft.

| Month. | inches. |
|---|---|
| January .. .. .. | 4·47 |
| February .. .. .. | 3·75 |
| March .. .. .. .. | 4·13 |
| April .. .. .. .. | 2·94 |
| May .. .. .. .. | 3·10 |
| June .. .. .. .. | 3·22 |
| July .. .. .. .. | 3·93 |
| August .. .. .. | 4·38 |
| September .. .. .. | 3·24 |
| October .. .. .. | 4·91 |
| November .. .. .. | 4·68 |
| December .. .. .. | 5·67 |
| Year .. .. .. | 48·42 |

Somerset—Chewton Mendip (The Priory), 51° 16′ N. 2° 35′ W. 550 ft.

| | |
|---|---|
| January .. .. .. | 3·84 |
| February .. .. .. | 3·37 |
| March .. .. .. .. | 3·57 |
| April .. .. .. .. | 2·97 |
| May .. .. .. .. | 2·76 |
| June .. .. .. | 2·96 |
| July .. .. .. .. | 3·49 |
| August .. .. .. | 4·49 |
| September .. .. .. | 3·07 |
| October .. .. .. | 4·82 |
| November .. .. .. | 4·28 |
| December .. .. .. | 5·38 |
| Year .. .. .. | 45·00 |

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# THE SOIL PROFILE IN VIEW OF FIELD STUDIES IN SOMERSET, DERBYSHIRE AND CHESHIRE

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## THE STUDY OF THE SOIL PROFILE.

THE study of the soil in this country has, until recent years, been confined largely to that part which is cultivated, about 10 inches in depth ; the material below has had comparatively little attention paid to it. A little reflection suggests that the surface soil, and the plants that grow in it, must be greatly influenced by the conditions down to, and often extending into the geological material from which the soil has developed ; the drainage and the composition of the soil water are two important factors which will be affected. Consequently, it is somewhat difficult to define accurately the limits of the soil, but in the study of any given region, if the unweathered parent material is 4 feet below the surface the whole of the 4 feet above must be studied, because it will probably influence those physical, chemical and biological changes taking place which give to the soil its colour, structure, mechanical composition and chemical composition. The vertical section, extending from the surface of the ground down to the parent material, is known as the *soil-profile*. It is divided into horizons, which are roughly horizontal, and sometimes these are clearly seen by colour change, but in other cases the differences are less noticeable, the difference perhaps being in chemical composition or other characteristics. These variations in the vertical section have resulted from the changes to which reference has already been made, for these are always working on the geological material, and the horizons are not determined arbitrarily but because of certain differences found as our study of the section proceeds from the surface downwards. The upper horizons are in many soils subject to leaching, and are referred to as the eluviated horizons. The leached material is frequently deposited lower down in the soil and these lower horizons are those of illuviation. But it may happen that the leached material is carried up again in solution and deposited so that the same horizon may at one time be one of eluviation and at another time one of illuviation. The horizons of eluviation are sometimes referred to as the A, those of illuviation, the B, and the parent material the C horizons.

We must consider the structure which is the result of the play of physical, chemical and biological activities, the first playing the most important part. The parent material from which the soil is formed is broken up by the action of frost and rain, and the finer particles are washed from the surface where the change has taken place, either down slopes or vertically into the soil, so that the texture at different levels is altered, the upper horizons containing a greater proportion of the coarse material and the lower of finer. Thus the uppermost horizon may be a fine sandy loam whilst 2 feet below the surface, the texture may be that of a silty clay loam.

There are a number of chemical changes at work in the soil and on the parent material. The speed of many of these is controlled by the temperature, and this will

be referred to later. Obviously the chemical changes will vary with different materials. The most important of the many changes taking place are (1) hydrolysis of the alumino ferro silicates and other substances giving silica and sesquioxides, (2) humic acids formed from the decomposing organic matter, (3) neutralization of the acids formed (i.e. salt formation), (4) conversion of carbonates into the soluble bicarbonates by the action of carbonic acid, (5) oxidation by atmospheric oxygen either directly or through bacterial action, (6) reduction, particularly of ferric iron to ferrous. All these changes are interrelated. If the base status is low, the humic acids are not neutralized, and the soil becomes acid in reaction. Also, the silicic acid and sesquioxides formed as a result of hydrolysis are colloidal, and if the humic acids are not neutralized, they exert a protective action on the iron and aluminium sols, and the complex iron plus aluminium hydroxides plus humic acids are carried down in the colloid state, and may be deposited where the conditions are such as to favour the conversion of the sols to gels. If, however, the humic acids are neutralized, e.g. by calcium compounds, then the movement of the iron and aluminium becomes slight, and the compounds of these elements are fairly uniformly distributed through the soil.

In a sample taken from any horizon, the products of weathering will be found with the clay fraction.* In temperate climates, the iron and aluminium hydroxides, set free by hydrolysis may pass downwards or remain more or less *in situ* as already explained, but the silicic acid tends to remain where it is set free. Thus, as hydrolysis is taking place largely near the surface, the value of the silicic acid will tend to become less in the lower horizons where less hydrolysis has taken place, whereas if the surface conditions are such as to allow the movement of the $Al_2 O_3 Fe_2 O_3$ complex there may be a steady increase in the proportion of these reaching a maximum in the illuviated horizons, then falling off in the C. If, however, the conditions do not favour the movement of the $Al_2 O_3 Fe_2 O_3$ complex, the analysis gives a fairly steady value in the different horizons for these constituents, the analysis being made of the clay complex.

The colour of the soil is controlled largely by the state of the iron compounds. In the ferric state the colours are red to brown whilst in the ferrous they are blue to greyish-blue. The colour of the surface is affected to a big extent by the humus content, and whether it is acid or neutral.

The biological activities are closely related to the chemical changes, many of which are brought about as a result of the activities of bacteria. The hydrogen ion concentration is an important factor in determining the kinds and numbers in the micro-organisms of the soil.

In the changes just detailed, there are two major factors (1) the climate, (2) the geological material. The temperature influences the velocity of the chemical reaction, which increases rapidly with rise in temperature, so that we may expect to find differences in soil type with change of latitude. The rainfall is an equally important climatic factor ; conditions may be such that the predominating movement of the water is downwards throughout the year, or there may be seasonal variation with an upward movement predominating for a part of the year, and obviously these will profoundly affect the chemical changes and the composition of the different horizons. The geological material plays an important part in soil-formation in equable temperate climates like that of

* The clay fraction is the material in the soil below ·002 mm. in diameter (the standard is much debated). The material below this size is mainly the colloidal products of the chemical weathering, and is chemically the most reactive part of the soil.

England, but it is of less importance in countries where the climate is more extreme, as in Russia. We may divide the geological materials into three groups: (i) those which, on weathering, give a soil with a low base value, e.g. most sandstones; (ii) those with a fair base value, e.g. dolerite; and (iii) those with a high base value, e.g. Lower Lias limestone. On sandstones, an acid surface-layer is common, and the movement of the protected iron aluminium sols takes place as described whereas in cases (ii) and (iii) this does not take place or to a less extent.

The soils of the world are by some divided into three groups: zonal, intrazonal and azonal, but the boundary is not always clearly defined except in countries like Russia. Here as one traverses from the North-West to the South-East one passes over belts of soils (a) the *Tundra* where the temperature is so low that the chemical and biological activities are very slight; (b) the *Podsols*, where the temperature is higher, cool temperate climate; (c) *Grey Forest Soils* (degraded Tshernosem); (d) the *Tshernosem* (cold winters—hot dry summers); (e) *Chestnut Soils*; (f) *Grey Desert Soils*. This classification, i.e. into zonal, azonal and intrazonal is on a basis of climate; the zonal soils are those characteristic of the climatic zones, as the succession just given, where the *climate* is the determining factor, the intrazonal soils are those in which the parent material is the determining factor, and the azonal soils are skeletal or partially developed materials such as alluvial soils. This classification is due largely to Sibirtzev.

Ramann classified the soils into Humid and Arid.

A. HUMID. (1) *Podsols*—sub-divided into geographical groups distinguished by degree of podsolization. (2) *Brown Earths*. (3) *Yellow* or *Red Earths*.

B. ARID. (1) *Tshernosems*. (2) *Chestnut Earths*. (3) *Grey Desert*, *Saline* and *Alkaline Soils*.

Glinka bases his classification on maturity of profile.

A. ECTODYNAMOMORPHIC—those in which the external factors of soil formation predominantly affect the soil characters. (1) *Laterites*, *Red Earths*, *Yellow Earths*. (2) *Podsols*, *Grey Forest Soils*, degraded Tshernosems. (3) *Tshernosems*. (4) *Chestnut Earths* and related types. (5) *Peat Soils* and *Mountain Soils*. (6) *Saline* and *Alkaline Soils*.

B. ENDODYNAMOMORPHIC—in which parent material predominantly affects the soil character. (1) *Rendzina*—humus carbonate soils. (2) *Skeletal Soils*—immature as are many of the upland soils of Britain.

Numerous modifications of these classifications have been suggested, but they represent different aspects of the above.

The soils of England, in Sibirtzev's classification fall into the zonal group—Podsol, but both azonal and intrazonal soils are common. In the classification of Ramann, the English soils fall into group A, and all three sub-divisions are found. And lastly, in Glinka's scheme, both Ectodynamomorphic and Endodynamomorphic soils are found, of the former Podsols, Peat Soils and Mountain Soils, whilst in the Ectodynamomorphic Rendzina and Skeletal Soils.

Whichever scheme we use (for classifying English soils) the Brown Earths of Ramann (being weakly podsolized podsols in Glinka's classification) have a place. English soils are nearly all either weakly podsolized, that is are Brown Earths of Ramann, or are Podsols.

We shall now consider in some detail the chief characteristics of the soil groups found in Britain. The following soils will be considered :—

(1) *Podsols.*

(2) *Brown Earths* of Ramann.

(3) *Rendzinas.*

(4) Some local soils :

(a) *Humus Soils*—sub aqueous.

(b) Soils under influence of ground water—*Glei.*

(c) Soils receiving continual additions of material—*Warp Soils.*

PODSOLS.

These are typically developed in a humid temperate climate on sands where the base status is low. Acid humus is formed, particularly from conifers which can grow on soils very deficient in the minerals required by most plants, and this protects the colloidal iron and aluminium hydroxides formed by the hydrolysis of the silicates, and the humic acids and iron and aluminium hydroxides travel together downwards into the ground. In the lower horizons, the presence of electrolytes causes the precipitation of the colloids in the gel form, and an accumulation is there formed. Thus the iron compounds which give colour to the soil are removed from the A horizon, giving its lower part a bleached appearance and, in those extreme cases in which *all* the iron is removed, a greyish-white colour. The A horizon thus consists essentially of two parts—the upper dark brown horizon of decomposing plant remains and the lower bleached horizon. The horizon of illuviation, known as the B horizon, contains the precipitated humus and sesquioxides, the sesquioxides being less in quantity than the humus. When there are two distinct B horizons, one above, of humus, which is black, with one below of iron-aluminium hydroxides, which is reddish-brown or orange-brown, the soil is known as a humus podsol. In less extreme cases, there may be no accumulation of humus, only a horizon with hydrated ferric oxide, giving what is known as an iron podsol. Below the horizons A and B is the parent-material, referred to as the C horizon.

For the formation of the extreme podsol, leaching must be intense, and the base status must be low. On loams and clays where the base status is higher, the podsolized horizon is much less marked and may even be undetected without chemical analysis.

Besides chemical eluviation, there is usually mechanical eluviation which, by forming a clay horizon, may lead to drainage impedance, even when the parent material is a fairly porous sandstone.

Thus a podsol may be identified when seen in section by : (1) A dark brown or black surface horizon containing decomposing plant remains. (2) A bleached horizon, almost white in some cases. (3) A black humus deposit, which may not, however, be marked in an iron podsol. (4) A reddish rusty brown to orange-brown horizon, the colour due to ferric oxide. (5) Parent material.

BROWN EARTHS.

The Brown Earths of Ramann occur naturally under deciduous forest. They are leached soils, but in warm dry years, slightly arid conditions may prevail so that the effects of the ascent of ground water are seen with possibly some enrichment of the upper

horizons with substances such as calcium carbonate. But the sesquioxides are retained and not passed down as in the podsols owing to the much higher base status of these soils. This higher base status may be due to less intense leaching, or parent material richer in basic reserves. The return to the soil of the leaves of deciduous forests is an important factor in maintaining the base status whilst the ground vegetation and the many earth worms help to maintain the circulation. Owing to the deficient translocation of sesquioxides the colour is remarkably uniform, varying from yellowish-brown to reddish-brown, the colour depending on differences in amount of yellowish-brown and brown hydroxides of iron, lighter yellow-brown or dark brownish-red not being rare. The silicates then have decomposed giving ferric oxide and other substances, but, as already stated, they remain more or less where the hydrolysis takes place, and are evenly distributed through much or all of the profile giving it a fairly uniform colour, striking

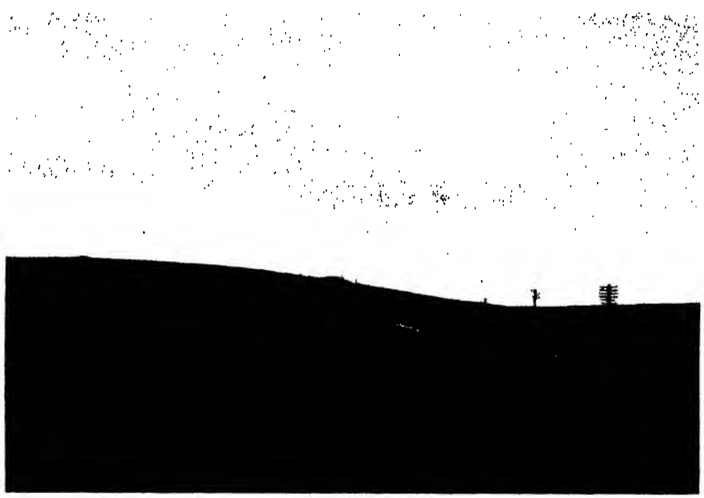


Fig. 1.—View on the Mendip Hills near Priddy.

contrast with the podsols in which, owing to the acid conditions, translocation of the sesquioxide does take place, giving the characters previously described. It is shown later that podsols and brown earths may occur under the same climatic conditions, the parent material being the deciding factor.

In the Brown Earths, the humus occurs principally in the form of an intimate mixture of the humus substances with the mineral portion of the soil. The soil has a neutral or slightly alkaline reaction, so that readily dispersed humus bodies are not found. Besides the ferric hydroxide, the brown earths are fairly rich in alumino silicates, so that they are usually tenacious or binding soils.

In Eastern Europe, on account of the continental situation, the climatic differences are much sharper than in Western Europe, and frequently podsols and tshernosems border one another.

The soils formed by weathering of calcareous rocks will now be considered. The Brown Earths, as might be expected, have many local soils, and there is change very quickly from one soil to another. The soils formed by the weathering of calcareous rocks

are examples of the local soils. The silicate rocks only lose a small proportion of their bulk during weathering, but a limestone may lose all its calcium carbonate, and the purer the limestone, the less the residue, it thus happens that some limestones containing a considerable amount of hydrated silicates give heavy soils on weathering. In very moist districts, it is possible for the residues after leaching to give a podsol owing to the low base status. One of the most notable features of most limestones is their jointed structure which leads to a very free drainage, so that the majority of soils formed on such rocks are not influenced by ground water, and the plants frequently suffer from lack of moisture as there is little or no upward movement during dry weather. Lack of water is, however, not met with in all limestone soils, e.g. on that of the Lower Lias in which, there being a high proportion of silicates, a heavy soil is produced. Also here bands of calcareous shale alternate with the hard blue limestone, and these stop free drainage which is so characteristic of Carboniferous limestone. The Carboniferous limestone soils being dry, have a low specific heat, so that they are " warm ", warmer than an adjacent soil formed from a sandstone. Consequently kinds of soil, characteristic of warmer climates are found on some limestones in England and other countries.

Humus formation on calcareous soils (in which there is calcium carbonate in the upper horizons) often leads to the formation of black humous substances. Many soil-bacteria flourish in the presence of calcium carbonate, and so the decay of peat is promoted by the addition of calcium carbonate (see Peat Soils). Dark coloured humous carbonate-soils are frequently called Rendzinas, and are typical of the Endodynamomorphic soils of Glinka's Classification. In a Rendzina, there is no red horizon (B) of iron accumulation, and the upper horizons are frequently quite rich in calcium carbonate (see Lower Lias Soils).

Another group of soils formed on limestone are red to reddish-brown in colour, but in these the base status is deficient, being base unsaturated. They are usually formed on hard limestone, and are fairly heavy in texture, the clay being well distributed. The sesquioxides also are evenly distributed. The profile is thus simple, being red to reddish-brown at the surface passing into a red soil which in turn passes sharply to the limestone below it. The origin of this red horizon is much debated, H. Stremme considering it to be the B horizon of the Podsols (see Menwood series), whereas A. Reifenberg considers that there is an irreversible precipitation in the surface horizons of sesquioxide sols peptized by silicic acid.

Be this as it may, we have two groups of soils formed from limestones, on the one hand those having a high base status with excess calcium carbonate, containing dark coloured organic matter associated with a siliceous type of clay, and probably containing no free sesquioxides, and on the other hand those with a low base status containing a type of organic matter giving a lighter colour and having some free sesquioxides. This second group appears to follow the desaturation of the soil, so that the red limestone soil is more mature than the grey Rendzina.

Peat usually forms the basis of humous soils. Peat soils vary according to the plants from which they have been formed. They may be divided into three groups :—

(1) Fen peat whereby expanses of water have been converted into peat.
(2) Forest peat, from the remains of trees.
(3) Moorland peat, from moss flora.

Fen peat is formed by the transformation of stagnant or slowly moving water into land, the dominant plant species varying in different climates. The dominant plants

also depend to a large extent on the water-content of nutrients so that distinctions can be made between soft and hard water formations. The temperature of peat soil corresponds with its high water content, the upper layers being cooler during periods of high temperature than mineral soils, but warmer when the temperature is falling, so that they have lower Spring but higher Autumn temperatures than mineral soils. It is probable that the lower average temperature especially during Spring and Summer rather than the lack of oxygen retards the decay of the plant remains and so is responsible for the accumulation of peat.

The most important modifying agent on peat is connected with its leaching by seepage water. Peats, especially those loosely packed, are fairly permeable to water, so that if a slow stream flows from the higher towards the lower part of the moor and the rainfall is fairly heavy, the peat-soil is subject to a continuous leaching of its minerals.

Fig. 2.—The Moor, near Godney.

The amount of evaporation from the surface is considerable so that the water-content of the upper layers is diminished and conditions are created that bring about the separation of unstable compounds, such as deposits of ferric hydroxide and calcium carbonate. The compounds are usually distributed throughout the whole mass or deposited in smaller or larger concretions, the form of the occurrence suggesting that the accumulations are formed by ascending ground water rich in these substances.

Many soils are formed under the influence of ground water, in which ferrous bicarbonate is often present in solution and, on the whole, ferrous bicarbonate is found in larger quantities when conditions favour the deposition of humus and the formation of colloidal solutions. Ferric ions are easily reduced by humous bodies whilst hydrated ferric hydroxide is not attacked directly. The general occurrence of salts of iron in solution in the drainage water of the lower levels of the soil, proves, however, that changes do take place leading to the formation of soluble iron compounds. In the absence of oxygen, the ferrous compounds are stable in solution, but are oxidized, on the access of oxygen, into ferric hydroxide. The deposition of ferric hydroxide is promoted by all influences favouring the ascent of ground water, including the action of plants.

The ferric hydroxide may be either uniformly mixed with the soil, or in streaks or veins from the average water level, or roots may be covered and particles may be cemented together.

Wysotsky has called these deposits Glei Soils—i.e. deposits formed in the soil by the rise of ground water. They are not restricted to level ground, but are also found on slopes carrying ground water.

Alluvial or Warp soils are formed in deposits made by rivers, and as long as these soils lie within reach of regularly recurring floods, they receive material transported from other regions, so that they are greatly dependent on the geological nature of the districts drained by the rivers. During the period of non-flooding, they are subjected to the weathering prevailing in the district. Frequently, they abound in Glei structures.

## GENERAL ACCOUNT OF THE PRESENT KNOWLEDGE OF ENGLISH AND WELSH SOIL PROFILES.

In Wales, a considerable amount of work has been done under the direction of G. W. Robinson. G. H. Gethin-Jones (1930) published a study of the pedogenic processes in an area of Lower Palaeozoic Shales in which he makes special reference to podsol soils which were developed on those rocks. A general survey is made of the soils of North Wales, and reports have been issued in which general accounts of the principal series are given by Robinson, G. W., Hughes, D. O., Brynmor Jones (1930). G. W. Robinson (1930) published a paper on the development of the soil profile in North Wales as illustrated by the character of the clay fraction and states that the mature profile over most of the lowlands is of the Brown Earth type. But there are few well developed profiles because (1) the eluviated horizons are denuded owing to the hilly country, (2) sands are uncommon, (3) the rocks are hard. The B horizon generally extends into the parent rock. Only by a study of the weathered part of the profile, the clay complex, can any real knowledge of the changes taking place be obtained. He describes soils from which it is clear that, with the better pastures, there is no sharp differentiation into ferruginous layers and so on, as obtains on the poor and waste land. In general, the soils of North Wales are brown to reddish-brown, this being especially apparent after treatment with hydrogen peroxide. The clearing of the land has led to soil-erosion, for there is little doubt that in primitive times the soils were podsols, which were destroyed during the medieval period by the denudation of the upper layers of the soil-profile. Under pastures the illuviated horizons remaining would gradually assume the characters of a podsol again. The soils are usually loams, and if sands occurred, they would be more podsolic. Red soils are found on the Carboniferous limestone which may be classified with the terra rossa. The grassland of North Wales is artificial, and when left, the land becomes covered first with scrub and finally with forest.

In Europe, the Brown Earths adjoin the Black Earths on the side on which humidity is lower, and the Red Earths on the other on which the temperature is higher. In North Wales the humidity is higher and the temperature is higher than in mid-Europe, being near the upper limit for both factors, thus a rise in temperature gives Red Earths and an increase in humidity gives podsols.

Robinson and Hill (1918-19) give a brief account of the Carboniferous limestone soils of Anglesey, North Caernarvonshire, both sides of the Vale of Clwyd and a considerable tract of Flintshire. The grassland is better than that of the older Palaeozoic

soils, the colour being reddish on light brown sandy loams, many of these contain little or no calcium carbonate despite the fact that the corresponding rainfalls are not excessive, being 30 inches at the Orme, Llandudno.

Brade-Birks and Furneaux (1928a) published a paper describing their studies of some typical profiles of a part of Kent. They came to the conclusion that all the soils described in their paper fall into Type VI—Peat and Ashy Soils of Sibirtzev's Classification (Tulaikoff 1908). In the same year, they published a paper on the formation of pans in podsol soils (1928b) in which they state that a clay pan forms at the water table owing to the indiffusibility of the descending colloidal clay. Subsequently colloidal iron as hydroxide descends and cannot pass through the clay pans and so forms a cement in the layer immediately above. This work was followed by a further account of profiles in Kent, Brade-Birks (1929) including a general account of soil profiles.

Fig. 3.—The Moors, near Godney. Godney Series developed here.

Brade-Birks and Furneaux (1930) published a soil map of a small area in Kent using the method adopted by the Americans in their system of soil classification. This was the first map of its kind to be published in this country.

Linwood L. Lee (1931) published an account of the influence of geology and climate on soil types and a comparison of the soils of south-east England and central New Jersey. He concludes that both in New Jersey and in south-east England, the soil belts are very closely related to the geological formation. Podsolization in general is further advanced in the soils of central New Jersey than in those of south-east England.

Further work on the Kent soils includes that of Furneaux (1932) on the High Weald of Kent and a study of soil-profile in relation to pasture performance in Romney Marsh (Cole and Dubey 1932).

Some of the profiles in Yorkshire were described in the British Association report 3, 1927. Fairly typical podsols are described, as well as soils which show no evidence of

podsolization in which the calcium is very high. In 1929 H. Trefor Jones and J. S. Willcox suggested that podsols probably cover the greater part of the uncultivated soils of Great Britain, they having found this to be true of those examined by them in Yorkshire.

According to Morison (1929) the agricultural lands of Great Britain and Ireland are Brown Soils in which there is an oscillation of the B solubility-horizon maintaining normal skeleton and humus profiles, so as to ensure uniform distribution of sesquioxides throughout the profile. The nature of the parent material is such that initially there is only a slow loss of soluble substances, and much of what is lost in Winter is regained by the upper horizons in Summer, and in some cases there may be an actual gain in these soluble substances. In this environment, the parent material, and through it the skeletal profile, will continue to exert a maximum effect upon the character of the whole section. Thus the typical Brown Soils of these islands are stable immature soils with their stability conditioned by oscillation of the solubility-profile, the rate of movement of this depending upon the physical nature of the parent material.

## The Subjects of the Present Enquiry.

It is now proposed to show by consideration of the results of a detailed field examination of three English areas, the place of a number of English soils in the scheme of International Classification. The areas concerned are (i) a part of central Somerset, (ii) north-west Cheshire (Wirral), (iii) a part of Derbyshire, and their detailed study enables the present investigator also to discuss certain general relationships between climate and parent material.

## Methods of the Present Enquiry.

Wherever possible, the soils found in woods have been examined, as these represent as far as is possible in this country, undisturbed profiles such as might be developed under natural conditions. Where this has not been possible smooth level ground under grass has been chosen where possible, and in the case of the Carboniferous limestone soils, gently undulating upland pastures. But in many cases, the profiles are those developed after centuries of cultivation or grazing.

## Soils on Alluvial Material and Peat in Somerset.

In the Appendix will be found descriptions of the chief profiles developed in the Central Somerset region. The first eight series described are good examples of local soils falling into the humous sub-aqueous group and associated soils. They are developed in the lowland region which was at one time largely under water, but is now only subject to periodic flooding. The Westhay series is very widely distributed. The surface of the peat (fen peat) rapidly weathers, particularly where it receives deposits of calcareous silt or is treated with crushed limestone, forming black silty loam very rich in organic matter. The water table is usually high, and often the ground is water-logged during the winter months. The streams that flow through the moorland have their source in the higher land of the Mendips, which, apart from the old Red Sandstone consists of limestones and other calcareous rocks, and consequently the water and the mud it brings down must be rich in calcium bicarbonate and other calcium compounds. In many fields small white grains which effervesce vigorously with hydrochloric acid are found (see Southway Series). Some of these appear to be very small shells, others are small white particles. There are two explanations of the presence of these white particles :

Fig. 4.—Dip Slope of Lower Lias. Looking from Polden Hills towards Glastonbury, Somerset.

(1) that they were introduced artificially in times past; some farmers are still in the habit of marling their ground as this aids in the decomposition of the peat, but marling is not extensively practised now; (2) they are deposited when the ground-water moves up during the dry periods. The peaty loam has a pH of about 6, but where the calcium carbonate has accumulated it is neutral.

There are four series in which there is a varying amount of silt overlying the peat. The first, called the Muxham series, is not common. The profile described is an excellent example of a Glei soil (i.e. under the influence of ground water), and at the same time it is allied to the humous sub-aqueous group. The water-table is always high, and during the dry period, the water containing iron compounds moves up, and in the parts where oxygen is present, ferric oxide is deposited. The bluish-grey colours, characteristic of the Glei soils are also present. The Queens series is better drained, the bluish-grey colours being absent, the 4-8 inches horizon being brown. All carbonates, however, are leached. The West Knowle series is found on the land bordering the Triassic Marl, and frequently land marked Red Marl on the geological map is found to be alluvium. The surface soil resembles closely the striking red soil on the Trias Marl except that the colour is duller. In No. 123S, for three feet from the surface, the profile resembles closely those found on the Trias Red Marl, but the horizon between 36 inches and 45 inches is greyish in colour owing to the underlying peat. 210S is a shallow phase of the same series, and in this example also, the horizon immediately above the peat has been leached of iron compounds, or they have been reduced to the ferrous state.

The Edington series is found near the streams and rivers which overflow, depositing their load of silt, during the winter months. As already mentioned, these streams have their origin in a region of calcareous rocks so that the deposits from them are rich in calcium carbonate. During the period when the land is free from the flood waters, normal weathering of the soil takes place and this leads to leaching of the carbonates. The peat

Fig. 5.—Haddon Woods, Ness, Cheshire. Bunter Pebble Beds. No. 24S Haddon Series developed in this wood.

underlying the silt will react with the calcium carbonate, so that we have first an increase in the amount of calcium carbonate followed by a decrease. This is illustrated by the figures of the carbonate values in Table I. The Glei effects are also obtained in the lower horizons, but the upper horizons have the yellowish-brown colour which is found on the calcareous soils of the Lower Lias. This is then an example of a Warp soil with Glei features also.

The Godney series has only a comparatively thin layer of peat and below this is a bluish-grey clay loam, passing into a soft bluish clay which effervesces vigorously with hydrochloric acid. Below the peat horizon, the bluish-grey clay is iron-stained, but this becomes less, finally disappearing as we descend. The Backwear series is similar except that there is no upper horizon of peaty material, in its place being a dark brown to greyish-brown silt loam. The horizons below are the same as the Godney series. These soils form a strip down the centre of the moorland, and it may be the calcareous mud deposit of a sluggish river which flowed across the moors. Both north and south of this strip, the peat is usually thicker as evidenced by the sections obtained during peat digging. The moor alluvium, however, is underlain by the Lower Lias clay and this blue clay may be the Lower Lias.

Travelling from Glastonbury to Bason Bridge through Meare and Catcott Burtle, there is a sudden change in the scenery after passing through the latter village. Hedges replace the rhines which separate the fields on the peat land, and at the entrance to fields and in the ditches one sees everywhere a bluish-grey clay. The ditches are deep, for the land is only a few feet above sea level. This grey clay extends for many miles, and is quite good dairy land, although it is rarely ploughed. The water-table is lower on this land than on the peat moors, and although it is nearer the sea, it is slightly higher than the peat moorlands, which are further inland. The profiles are everywhere fairly similar, but there are certain differences to be pointed out. No. 19S (Mark Series) is typical of much of this area. The colour change is not great, the upper horizons being grey, the lower bluish-grey to blue. The texture becomes slightly heavier in the lower horizons. The upper horizons are free from iron stains and in most cases are leached of calcium carbonate, although they are neutral to alkaline in reaction. Some, however, with a higher water-table have a little calcium carbonate in the surface horizon. But in all the soils examined, the accumulation of ferric oxide commences at 12-20 inches. At first it is usually slight, then it increases in amount, then it falls off again until often there is very little. This is followed by another increase then a decrease as before. This variation is well illustrated by the profile descriptions (see sections). It is seen that this is sometimes repeated down to 54 inches, but in other cases it ends nearer the surface, and the lower part of the profile is a blue to bluish-grey clay. Three Series have been identified, Mark A, Mark B and Mark C, the chief difference being in the carbonate content of the horizons. In all soils of this type, there are carbonates, the depth at which they occur in quantity varying.

The country from Glastonbury to the Bristol Channel, now drained by the River Brue and many artificial channels was originally a swampy morass. At Meare and near Godney there is the remains of a lake village. The moorland was largely under water, and the district now covered by this greyish-blue alluvial material must have had at one time a much higher water-table than at the present day. It would then be a ground-water soil. To-day, the water-table is often at a depth of 3 feet to 4 feet 6 inches, and the land is not subject to flooding like the peat moors. The colour and the horizons of ferric hydroxide are suggestive of the Glei soils, but they are obviously not the same

as the Muxham and Edington Series. It is suggested that the Mark series was a Glei soil, but as a result of drainage, particularly of the hinterland, which has been going on from at least Roman times, it has become less and less a ground-water soil. To-day, the upper horizons have become free of the ferric hydroxide deposits and largely leached of the carbonates. As would be expected in a soil of this type there is little or no deposit of

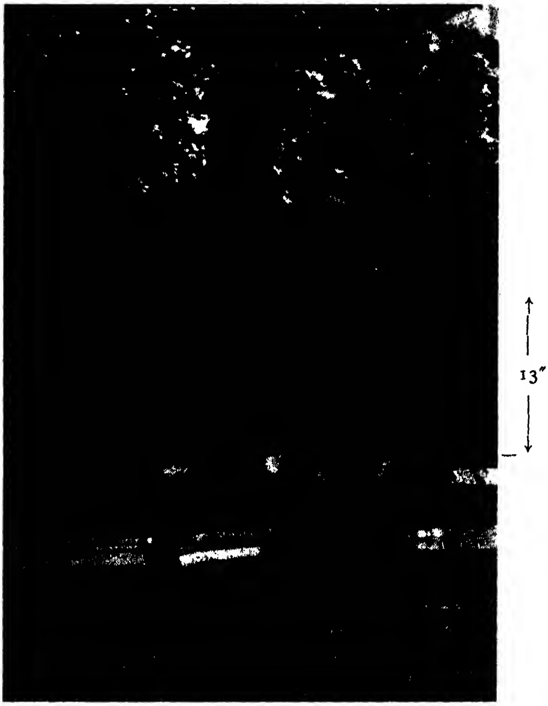



Fig. 6.—245S. Geology: Lower Lias. Origin: Sedentary. Colour: Chocolate-brown. Topography: Slight slope to North. Drainage: Good.

Profile: vigorous evolution of $CO_2$ with hydrochloric acid
- 0—11″ Chocolate-brown silt loam becoming lighter brown silty clay loam.
- 11″—13″ Yellowish-brown clay loam.
- 13″ Limestone.

pH.
1″=7·0—8·0
5″=7·0—8·0
12″=7·0—8·0

the ferric hydroxide below the present water-table. Enrichment of the iron accumulations no doubt still takes place during the drier part of the year. This is a very characteristic soil for a number of square miles in this part of Somerset.

Summing up, the Alluvial soils of this region of Somerset may be divided into five groups :—

I. Humous sub-aqueous group. These have a very simple profile with calcium carbonate concretions in some cases ; the water-table is always high. Widely distributed, e.g. Westhay and Southway Series.

II. Typical Glei soils, free from carbonates, e.g. Muxham Series.

III. Warp soils with a Glei structure also, e.g. Edington Series.

IV. Thin humous-peat, with varying degree of decomposition overlying blue calcareous clay, e.g. Godney and Backwear Series.

V. Altered Glei soil, due to change in water-table, covering a wide area, e.g. Mark Series.

At Catcott Burtle there is a deposit of sand and shells known as the Burtle Beds. It is the only sand in this part of Somerset, and the soil developed on it has the character of a podsol (see Catcott Series). There is first a greyish-brown horizon followed by a bleached one. Below this is a grey iron stained horizon of illuviation followed by the parent material—a sand, sometimes mixed with shells and giving a vigorous effervescence with hydrochloric acid. The influence of the parent material is exhibited very clearly in this soil. It has already been pointed out that podsols are developed on sands where the base status is low. On these beds, the sandy texture will enable a rapid leaching of the calcium carbonate to take place, and the siliceous material left is suitable for the development of a podsol. The climate also favours podsol development, so the profile already described is produced.

## SOILS ON CALCAREOUS ROCKS IN SOMERSET.

The remaining soils studied in this region of Somerset belong to the intrazonal group of Sibirtzev's classification, i.e. those in which parent material plays an all important part. In Ramann's classification, they are in the humid group, being in some cases Brown Earths and in others Red Earths. In the classification of Glinka, they are all typical Endodynamomorphic soils.

The two chief groups of limestone soils already described are developed (i) on hard limestone, (ii) on softer and more siliceous rock. The first group to be considered will be of those on the hard limestone of the Mendip Hills, Carboniferous limestone.

On the Carboniferous limestone of the Mendips, two series have been distinguished, one under woodland and the other under grass or the plough. The greater part of the country is now under grass, and the Mendip series (see sections) is widely distributed. It is a simple profile consisting of a light brown to reddish-brown loam in the upper horizons, becoming a yellowish-brown to red silt loam in the lower horizon, the different colours in the lower horizon appearing to be due to different drainage conditions. This is followed by the limestone. There is no clear differentiation into horizons as in the podsols. Wherever the soil is ploughed, the colour of the surface is very reddish-brown. and even when the land is under bracken, the upper horizon is very reddish in colour. Neither in the Mendip nor Menwood series (to be described later) is the water-table ever reached, so that drainage is not only free but excessive in most cases, the grass being usually brownish in colour in sharp contrast with the green of the moorland pastures. In all the soils examined in this series, there is a complete leaching of carbonates (see Tables, Low, 1934). Many of the upper horizons are slightly acid, others being neutral, whilst the lower horizons are neutral. As regards textural changes, there is an increase from the surface downwards. The uppermost horizon is usually a loam to silty loam, and as the parent material is approached, this passes through silt loam to silty clay loam and sometimes a clay loam. But the soils of the Mendip series are probably not the natural soils of the Carboniferous limestone of the Mendips, which were originally well

wooded. Owing to the mining of lead and other ores, these primitive forests have been removed. To-day, there are small patches here and there, some coniferous, others deciduous, and the Menwood series is the group of soils developed under deciduous woodland conditions. It is distinguished from the Mendip by the greyish-brown surface horizon which is covered with forest litter. Below this, however, there is a brown horizon

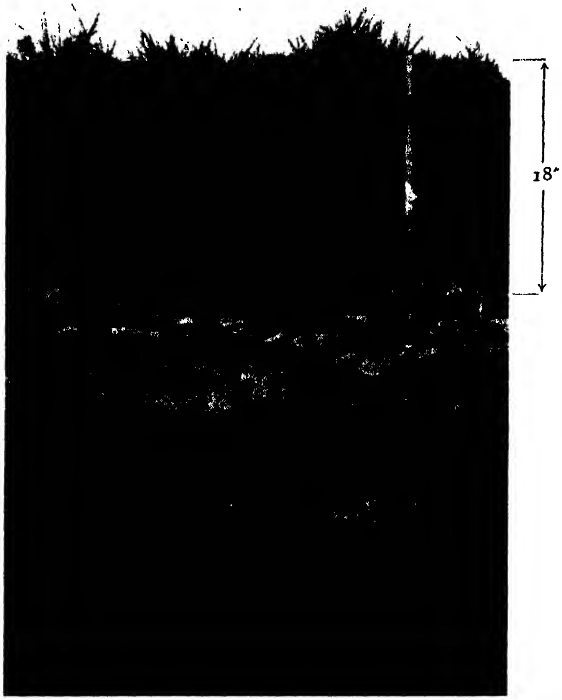



Fig. 7.—246S. Geology: Lower Lias. Origin: Sedentary, with some colluvial Lower Lias. Colour: Chocolate-brown. Topography: Flat. Drainage: Good.

Profile: vigorous evolution of $CO_2$ with hydrochloric acid.

- 0—7" Chocolate-brown silt loam.
- 7—12" Light greyish-brown silty clay loam.
- 12—18" Yellowish-brown, slightly rusty iron stained shale.
- 18" Hard Limestone.

pH.
1" = 7·0—8·0
6" = 7·0—8·0
12" = 7·0—8·0
18" = 7·0—8·0

which becomes reddish-brown before the parent material is reached. Under beech, as in 238S, there is some carbonate accumulation in the first few inches. This may be due to the leaf fall from this type of tree, a point which has already been referred to in the general description of Brown Earths (see page 169). For Menpod Series see Low 1934.

The Men Series is not more than half a mile from the Old Red Sandstone outcrop on Pen Hill. In No. 227S, the vegetation is conifers, and there is evidence of podsolization in the first 6 inches. Mixed with the soil are small stones which are not carbonate ;

they are probably fragments of Old Red Sandstone. The lower part of the profile resembles those of the Carboniferous limestone. This must be considered as a profile formed from sedentary limestone material and colluvial Old Red Sandstone. The Pen series has a great depth of Colluvial Old Red Sandstone, limestone not being found at 54 inches.

An important fact to be noted in considering the development of the soils on the Mendips is that the country has not been glaciated. Consequently, although the soil forming processes were slowed down or came to a standstill during the cold periods the present stage of development is probably the result of a very long period of formation. In Derbyshire, the Carboniferous limestone formation is also found, but this part of England was probably under the ice sheet, and the soil would be largely if not completely removed, so that the soil found there to-day has been developed since the glacial period. Consequently we should expect to find the soil in Derbyshire much shallower than in Somerset, and this is illustrated by the profiles described (see sections). The Red soil of the Mendips resembles the Terra Rossa of Southern France, which the author has examined, except that the colours are not so bright, and may represent a northerly occurrence of the Terra Rossa, a soil typical of a warmer climate. This has already been discussed and the reasons given for the warmer soil.

The other group of limestone soils is developed on the Lower Lias. Here, five series have been distinguished and of these the Street and Elmhurst are the most widely distributed. Topographically, the Street is usually found on level ground, whilst the Elmhurst is on slopes. The upper horizons of both are dark brown silt loams becoming yellowish-brown, but in the Elmhurst series, it passes directly to the rock from the yellowish-brown horizon whilst in the Street there is a layer of bluish-grey clay immediately above the rock. This bluish-grey clay seems to be the partially weathered limestone, oxygen being largely absent during the weathering. Free access of oxygen yields the yellowish-brown material when the limestone or clay weathers, and in the Elmhurst series, which is very much shallower than the Street, the yellowish-brown material is found down to the parent material, which is blue Lower Lias limestone. The presence of calcium carbonate in the surface layer is a distinguishing feature of these soils, and in some cases the percentage is high (see Table I).

Under woodland, there are certain marked differences in the soil-profile on the Lower Lias. The greyish-brown layer at the surface is much more marked. In the Loxley series (see sections) there is evidence of iron accumulation in the lower horizons, and this is often associated with a comparatively high water-table. The leaching of calcium carbonate is much more marked than on the cultivated soils, and the abrupt change in the percentage of calcium carbonate, particularly in 221S, is striking. It does not seem reasonable, if the leaching is downwards at all times of the year, that there should be an abrupt change from a horizon with no or almost no calcium carbonate to one with a relatively high percentage. It is suggested that during the dry periods, there is an upward movement of the soil water containing calcium bicarbonate, the calcium carbonate being deposited, and there are thus two opposing factors, resulting in a kind of equilibrium. The ground water may be moving slowly down the gentle dip slope on which these soils are found, and be saturated with calcium bicarbonate, so that it will not leach calcium carbonate from the soils found on the lower slopes. In the cultivated soils, the percentage of calcium carbonate in the surface layer is as much as 20. Cultivation will promote the upward movement of the soil water, and the aeration, produced at the same time, will help in the decomposition of the calcium bicarbonate, and its deposition in the upper horizons of the soil.

The Street, Elmhurst and Loxley series are developed on the Lower Lias limestone, but the Splotts and Blackford series are developed on the Lower Lias clay. The Splotts is similar to the Street, but the drainage is rather more impeded. The Blackford series, however (the example given is found in a wood), has no brown colours, being grey in the upper horizons and merging into the bluish clay of the Lower Lias. The drainage is poor, and this probably accounts for the absence of brown colours. As in other Lower Lias soils developed under woodland, the carbonate content is very low in the upper part of the profile, an abrupt change to a comparatively high percentage taking place about 2 feet below the surface.


Fig. 8.—252S. Coxley Series B. Geology: Trias, Red Marl. Origin: Sedentary and Colluvial Trias Marl. Colour: Reddish-brown. Topography: Fair slope to South. Drainage: Good.

| | |
|---|---|
| Profile: | 0—6″ Reddish-brown silty loam. |
| Vigorous evolution of $CO_2$ | 6—14″ Red silt loam. |
| with hydrochloric acid. | 14″ Red and greyish-white Trias Marl. |

| | pH. |
|---|---|
| 0—6″ | =7·0—8·0 |
| 6—14″ | =7·0—8·0 |
| 14″ | =7·0—8·0 |

The soils formed on the Lower Lias limestone differ very much from those found on the Carboniferous limestone of Somerset, although there is relatively little difference in the rainfall. In colour, they are greyish-brown to yellowish-brown as contrasted with the red to brownish-red of the Carboniferous limestone soils. All the soils of the Lower Lias contain calcium carbonate above the parent material, and in many cases this extends to the surface and is frequently high there, whereas the soils formed from the Carboniferous limestone are almost completely leached. The drainage also is very different, the water-table never being reached on the Carboniferous limestone, whereas it is frequently reached on the Lower Lias. Except in the Elmhurst series, there is a heavy clay horizon immediately above the parent material in the Lower Lias soils, and this must affect the drainage. As previously suggested, the presence of calcium carbonate at or near the surface and the abrupt changes in other cases from little or no calcium carbonate to comparatively high values suggests that in the dry months, there is an

upward movement of soil water. The general account given of the Rendzina soils on page 171 suggests that the soils developed on the Lower Lias must be placed in this group, the two most important factors being (1) the dark greyish-brown layer found in the relatively undisturbed soils and (2) the excess of calcium carbonate.

The Penarth beds are not exposed to any extent in this part of central Somerset. They consist of a large number of very thin beds, varying greatly over a small area. It is found that the soils also vary very much, so that it has not been possible to establish satisfactory soil series. As regards colour profile, they frequently resemble the soils of the Lower Lias in the upper horizons, being dark brown passing to yellowish-brown or reddish-brown. The lower horizons, however, are very varied, and probably represent slightly altered geological material. Much of the land is devoted to grass. In nearly all cases the whole, or at least the lower horizons, of the profile contain carbonates. The effect of parent material, which will be considered later, is obviously a very important factor in the soils formed from these Penarth beds. A number of profiles is described to illustrate the great variety.

The Triassic Marl in the part of Somerset studied is rich in calcium carbonate and gives rise to soils which do not differ greatly from one another, the chief differences being due to differences in the amount of leaching and in the impedance of drainage. When undisturbed, as in old orchards, the uppermost horizon is greyish-brown, but cultivation gives a brown to reddish-brown colour. When freshly ploughed, and considerable areas are cultivated, the red colour is very striking. The lower horizons are red in colour and merge imperceptibly into the parent material. Below the surface horizon, and passing down to the marl, the unchanged parent material, the chief distinction from this marl to be noted in the soil is the presence of small black specks of sesquioxides ; these frequently occur in bands and are probably associated with changes in water-table ; the presence of black particles is most marked where there is little or no carbonate, whereas in Coxley B, which is rich in carbonates, they are not found, whilst in Coxley C they are rare (see sections). It will be seen from the diagrams that the Trias Red Marl soil has been called the Coxley series and is sub-divided into A, B, C and D. Coxley D series has not been found widely distributed as yet, and occurs in old orchards, and the amount of calcium carbonate in the uppermost horizon is remarkably high. Coxley C series is leached of calcium carbonate in the upper horizons, but it gradually increases in amount until the parent material is reached. The drainage of Coxley C series is fairly good. In Coxley B series, there is a little calcium carbonate in the first 2 inches but it rapidly increases in amount reaching 15 per cent at 18 inches, but in this series, the parent material does not appear to contain more than 15 per cent of calcium carbonate. From the analysis, it is seen that the amount of calcium carbonate in the parent material, the Trias Marl, varies considerably. Coxley A is the most leached. The red colour of these soils is undoubtedly due to the same cause as that which gives the parent material its colour. They must be placed in Glinka's endodynamomorphic group, but they differ from the Lower Lias soils in their colour. They also contain a greater percentage of coarser materials than the Lower Lias soils. They may be classed provisionally with the Rendzinas, chiefly on the grounds of the high percentage of calcium carbonate and the greyish-brown uppermost horizon.

## SOILS ON CARBONIFEROUS LIMESTONE IN DERBYSHIRE.

Low (1934) describes some profiles developed on the Carboniferous limestone of Derbyshire. The climatic conditions are somewhat different from those of Somerset (see Low, 1934) and the effect of this is seen when the profiles of the Carboniferous

limestone of the Mendips are compared with those in Derbyshire. As in the case of the Somerset profiles (on the Carboniferous limestone) there is a complete leaching of calcium carbonate, and any other carbonates, and when we examine the colour profiles, which are some indication of the chemical changes that have been and are taking place, we find a marked difference from those in the Mendips. In the Derbyshire profiles, the uppermost horizon in each example given is either black or greyish-brown in colour. Except in 6D, which is at the top of a hill 1,350 feet in height, the horizon below the grey is brown until the parent material is reached. In some soils, a reddish tint appears, but it is never very marked. The general profile is a grey silty loam passing into a brown silty clay loam which passes abruptly to the parent material, the limestone. It has already been pointed out that the soils of warmer climates are found far north of their usual latitude on limestones, and an example of this is the Terra Rossa of the Mendips. But in Derbyshire, with a colder climate, it is more difficult for the soil typical of the warmer climate to be formed. Consequently the chemical changes resulting in the formation of the ferric compounds which give the red colour to the limestone soils of the Mendips, do not proceed to the same extent and consequently the brown colours predominate. Topographically both are formed on rolling country but the altitude of those in Derbyshire is on an average about 1,200 feet whilst that of those in the Mendips is about 800 feet. The Derbyshire soils resemble much more the typical Brown Earths, in which the carbonates are completely leached, and the pH values indicate a soil just on the border between neutral and slightly acid in the surface layers.

## SOILS IN NORTH-WEST CHESHIRE (WIRRAL).

The typical profiles of a region in north-west Cheshire have previously been described (Low, 1933). These profiles have been arranged in the order of the geological stratigraphy of this district, beginning with the Bunter Pebble Beds. Very few profiles are described on some formations because their outcrops cover such a small area, and because considerable parts of the Wirral are now covered with housing estates. Fourteen soil series have been established, and the same series is found in some cases on a number of different geological formations, but it must be noted that chemically, many of the beds do not differ greatly from one another.

### Bunter Pebble Beds.

If we consider the soils developed on the Bunter Pebble Beds, six series have been identified. These range from examples such as 29W of the Thornton series to 62W of the Haddon. The Thornton series is a brown sandy loam overlying the sandstone, and there is very little change of colour or texture in the profile. In the Hough series, there is a reddish coloured clay horizon which no doubt represents illuviated material. The Ness series has a more marked horizonation, 37W illustrating this. The eluviated horizon is from 0-22 inches, the illuviated horizon below being marked by the iron accumulation. The horizons of the Neston series differ from the preceding ones ; there is a marked layer of iron accumulation and also a considerable increase in the clay fraction. In the Brimstage series, the second horizon is heavily iron stained, the uppermost being brown or dark brown with no horizon suggesting marked removal of iron compounds ; below this is a leached horizon which is again succeeded by another horizon of iron accumulation. Finally, of the soils developed on the Bunter Pebble Beds, the Haddon series has the most marked colour profile, the eluviated and illuviated horizons being clearly seen. Considering 24W, 0-7 inches consists of the accumulated

organic matter, 7-11 inches is an horizon of eluviation, whilst 11-22 inches represents horizons of illuviation.

UPPER MOTTLED SANDSTONE.

These beds are not so widely exposed in the Wirral. Three series found on the Bunter Pebble Beds have been found on these beds also—the Ness, Neston and Haddon, but none found on Upper Mottled Sandstone alone.

BASEMENT BEDS.

Three series are identified on these beds, the Hough and Haddon which have been referred to already, and the Frankby which has not been found on other formations.

WATERSTONES.

Four series are identified on these beds, three having been noted already, the Greasby being the fourth, which has not been found on other formations.

KEUPER MARL.

There is very little exposed, and two series not found on other formations have been identified, the Irby and Arrowe.

The soils on the sandstones are still largely cultivated, and were no doubt cultivated still more in the past, so that we cannot expect to find many undisturbed profiles. However, on the Bunter Pebble Beds, Upper Mottled Sandstone and Basement Beds, there are pine woods, and stretches covered with bracken and gorse, and here we find good examples of podsols (see sections). Many are humous podsols, and in most cases, the upper layer of illuviation, consisting largely of black humus is well differentiated from the lower horizon in which the iron is most accumulated, and although the iron is distributed throughout the whole of the horizons of illuviation, the humous layer always seems to end abruptly and to be followed by a bright orange coloured sand. It is thus quite clear that on these beds, the soils developed under natural conditions are podsols, the humous podsol in many cases, and in the others, an iron podsol, the humous podsol probably representing the *mature* soil. Both the geological material and the climate are suitable for podsol formation.

But in the Wirral there is not a great number of podsols as fully developed as those in the Haddon Series. In all probability, all the other series described on these formations represent altered podsols. There are various reasons for the change. Removal of the forest covering leads to erosion of the upper horizons, and they may be washed down slopes, or removed by the wind, thus exposing either the lower eluviated horizons or even the illuviated part. If the latter be exposed, and cultivated, a soil of almost uniform colour down to the parent material may be obtained. Aeration of the soil will aid the decomposition of the organic matter, and the growth of plants will help to restore to the surface the material which has been leached. Cultivation can thus help to convert a typical podsol into a soil which, as far as colour profile is concerned, resembles the Brown Earths. The extreme case of this change is well illustrated by the Thornton series. But usually, there are clear signs of some podsolization in the soils of these Triassic sandstones, and the range from a typical podsol to a soil which in the field bears little likeness to it is well illustrated by the soil series of the Bunter Pebble Beds. In the Hough series, the reddish colour due to the iron in the illuviated horizon is noticed, and this is much more marked in the Ness and still more in the Neston, but it is only in

the Haddon that the bleached layer of the eluviated horizon is really clear. It is suggested that the Brimstage series has by erosion lost its eluviated horizons. Podsolization of the old illuviated horizon has commenced, so that we have a bleached horizon with horizons of iron accumulation above and below it. The Frankby series is another example of a truncated podsol and here the upper humous horizon of illuviation seems to form the surface of the present soil, and is now showing faint signs of podsolization. Immediately below this humous horizon is one that is heavily iron stained, also containing a considerable amount of humus.

A well developed podsol has not been found on the Waterstones. There are only two small outcrops, and a considerable part of one of these is covered with houses, and the remainder is chiefly arable. On this formation the Neston series is the most podsolized. It is probable that the Greasby series has some Boulder clay mixed with it, and there are signs of podsolization.

The soils of the Keuper Marl are not calcareous as in Somerset. The lower horizons, however, of the Irby series closely resemble those of the Coxley. The pH values of the two series should be compared (see Table II). It must be remembered that the Triassic deposits of Cheshire are not situated so close to limestone rocks as in Somerset, so that the formations do not necessarily correspond chemically, and so may give a different soil. The Arrowe series is very similar to the Ness, and might well be placed with it. Very little Keuper Marl is exposed, and no podsols of the Haddon series have been found on it.

The Boulder clay frequently contains sandy beds, and it has been assumed where sandstone or sand is found that this is a deposit formed at the same time as the Boulder clay, as it is marked Boulder clay on the geological map, but this is merely for convenience, and it seems probable that many of the boundaries are not quite correctly drawn. The Boulder clay is dark reddish-brown in colour, having the texture of a clay, but usually containing many sand grains. As with the standstone of the Trias, a number of series are found on the Boulder clay. The Poulton, Haddon and Brimstage have sand or sandstone in the lowest horizon examined. The Poulton resembles closely the Neston series. There are, however, three series which have Boulder clay for the lowest horizon, the Barnston, Storeton and Clatterbridge. The Barnston shows signs of podsolization with white sand grains in the uppermost horizon, and an illuviated horizon containing black particles of limonite. The eluviated horizon is more clearly defined in the Storeton series and so is the iron accumulation. The Clatterbridge series is a well devoloped podsol; fields in which the soil belongs to this series are fairly readily detected, the grass being very poor.

The climate of the Wirral does not differ greatly from that of Somerset, but whereas podsols are developed everywhere in the former, in the Somerset region studied, the soils belong to the Brown Earth and associated groups. But there is an exception in Somerset, on the Burtle Beds; here a typical podsol is formed (the soils of the moorland are not considered here as they can in no way be compared with those in the Cheshire and Derbyshire regions studied). The study of the field characters of the soils in these two regions having a similar climate illustrates very clearly the importance in England of the geological material in determining the kind of soil. The climate is not sufficiently extreme to be the dominant factor in determining the kind of soil, but given the same material from a chemical point of view, i.e. a sand consisting largely of silica, the same soil is developed in Somerset and Cheshire. But if the chemical difference is great, then the kinds of soil are quite different. The value of geological maps is very well illustrated by

this work, the soil boundaries usually corresponding with the geological. In the Somerset region considered, the Penarth formation consists of a larger number of very thin beds, differing considerably from one another. It is found that the soils also vary greatly over small areas.

When the climates of two areas of the same geological material are different there are differences in the soils developed. This is illustrated by the soils found over Carboniferous limestone in Derbyshire and in Somerset; in Somerset they resemble the Terra Rossa of Southern Europe, but in Derbyshire they resemble more the Brown Earths, and the Derbyshire climate is such that, on sandstones, very well developed podsols are formed.

TABLE I.

*Showing percentage of calcium carbonate in some typical profiles.*

| | |
|---|---|
| **Street Series No. 215S—Lower Lias Limestone.** | |
| 0–3½″ | 14·31% |
| 3½–10″ | 22·07% |
| 10–18″ | 21·69% |
| 18–24″ | 32·97% |
| 24–30″ | 35·87% |
| **Street Series, No. 218S—Lower Lias Limestone.** | |
| 0–2″ | 17·06% |
| 2–11″ | 26·37% |
| 11–15″ | 42·72% |
| 15–18″ | 41·83% |
| **Street Series, No. 220S—Lower Lias Limestone.** | |
| 0–3″ | 3·069% |
| 3–12″ | 8·53% |
| 12–17″ | 20·43% |
| 17–18″ | 53·20% |
| **Loxley Series, No. 214S—Lower Lias Limestone.** | |
| 0–16″ | 4·99% |
| 16–18″ | 5·09% |
| 18–19″ | 23·71% |
| 19–40″ | 26·84% |
| 40–50″ | 39·62% |
| **Loxley Series, No. 221S—Lower Lias Limestone.** | |
| 0–3″ | 0·49% |
| 3–18″ | 0·12% |
| 18–24″ | 20·75% |
| 24–30″ | 26·31% |
| **Blackford Series, No. 217S—Lower Lias Clay.** | |
| 0–24″ | 0·19% |
| 24–30″ | 7·05% |
| 30–48″ | 30·41% |
| **Coxley Series B, No. 222S—Trias—Red Marl.** | |
| 0–8″ | 8·01% |
| 8–18″ | 15·62% |
| 18″ | 15·16% |
| **Coxley Series C, No. 235S—Trias—Red Marl.** | |
| 0–9″ | 0·00% |
| 9–18″ | 1·89% |
| 18–30″ | 13·61% |
| 30–42″ | 23·04% |
| 42–54″ | 25·15% |

TABLE I.—*Continued.*

Coxley Series D, No. 234S—Trias—Red Marl.

| | |
|---|---|
| 0–3″ | 33·90% |
| 3–11″ | 22·75% |
| 11–18″ | 2·63% |
| 18–32″ | 15·98% |
| 32–42″ | 24·30% |
| 42–54″ | 30·99% |

Edington Series, No. IS.

| | |
|---|---|
| 0–4″ | 12·11% |
| 4–6″ | 14·90% |
| 6–10″ | 7·48% |
| 10–14″ | 4·20% |
| 14–54″ | 1·25% |

TABLE II.

*Approximate pH values (determined colorimetrically).*

85S—Godney Series.

| | pH. |
|---|---|
| 1″ | 5·5 |
| 18″ | 5·5 |
| 20″ | 7·0 |
| 54″ | 7·0 |

84S—Westhay Series.

| | pH. |
|---|---|
| 1″ | 6·0 |
| 18″ | 5·0–5·5 |
| 36″ | 5·0–5·5 |
| 54″ | 5·0–5·5 |

81S—Westhay Series.

| | pH. |
|---|---|
| 1″ | 6·0 |
| 12″ | 6·0 |
| 24″ | 5·5 |

80S—Southway Series.

| | pH. |
|---|---|
| 1″ | 6·0–7·0 |
| 8″ | 6·0–7·0 |
| 18″ | 5·5–6·0 |
| 36″ | 5·0 |

111S—Mark Series A.

| | pH. |
|---|---|
| 1″ | 7·0 |
| 18″ | 7·0 |
| 36″ | 7·0–8·0 |
| 54″ | 7·0–8·0 |

20S—Mark Series.

| | pH. |
|---|---|
| 1″ | 7·0–8·0 |
| 8″ | 7·0–8·0 |
| 18″ | 7·0–8·0 |
| 36″ | 7·0–8·0 |
| 54″ | 7·0–8·0 |

TABLE II.—*Continued.*

19S—Mark Series A.

| | pH. |
|---|---|
| 0–3″ | 7·0 |
| 3–8″ | 7·0–8·0 |
| 8–14″ | 7·0–8·0 |
| 14–20″ | 7·0–8·0 |
| 20–29″ | 7·0–8·0 |
| 29–46″ | 7·0–8·0 |
| 46–54″ | 7·0–8·0 |

1S—Edington Series.

| | pH. |
|---|---|
| 0–4″ | 7·0–8·0 |
| 4–6″ | 7·0–8·0 |
| 6–10″ | 7·0–8·0 |
| 10–14″ | 7·0–8·0 |
| 14–54″ | 7·0–8·0 |

166S—Edington Series.

| | pH. |
|---|---|
| 3″ | 7·0–8·0 |
| 16″ | 7·0–8·0 |
| 30″ | 7·0–8·0 |

165S—Edington Series.

| | pH. |
|---|---|
| 3″ | 7·0–8·0 |
| 11″ | 7·0–8·0 |
| 30″ | 7·0 |
| 50″ | 7·0 |

192S—Catcott Series.

| | pH. |
|---|---|
| 1″ | 6·0–7·0 |
| 8″ | 6·0–7·0 |
| 11″ | 6·0–7·0 |
| 18″ | 6·0–7·0 |
| 30″ | 7·0 |
| 35″ | 7·0–8·0 |

18S—Catcott Series.

| | pH. |
|---|---|
| 1″ | 6·0–7·0 |
| 8″ | 6·0–7·0 |
| 16″ | 6·0–7·0 |
| 26″ | 6·0–7·0 |
| 36″ | 7·0–8·0 |

246S—Elmhurst Series.

| | pH. |
|---|---|
| 1″ | 7·0–8·0 |
| 6″ | 7·0–8·0 |
| 12″ | 7·0–8·0 |
| 18″ | 7·0–8·0 |

245S—Elmhurst Series.

| | pH. |
|---|---|
| 1″ | 7·0–8·0 |
| 5″ | 7·0–8·0 |
| 12″ | 7·0–8·0 |

215S—Street Series.

| | pH. |
|---|---|
| 3″ | 7·0–8·0 |
| 12″ | 7·0–8·0 |
| 24″ | 7·0–8·0 |

TABLE II.—*Continued.*

244S—Street Series.

| | pH. |
|---|---|
| 1″ | 7·0–8·0 |
| 16″ | 7·0–8·0 |
| 24″ | 7·0–8·0 |
| 34″ | 7·0–8·0 |

220S—Street Series.

| | pH. |
|---|---|
| 0–3″ | 7·0 |
| 3–12″ | 7·0–8·0 |
| 12–17″ | 7·0–8·0 |
| 17–18″ | 7·0–8·0 |

218S—Street Series.

| | pH. |
|---|---|
| 0–2″ | 7·0–8·0 |
| 2–11″ | 7·0–8·0 |
| 11–15″ | 7·0–8·0 |
| 15–18″ | 7·0–8·0 |

217S—Blackford Series.

| | pH. |
|---|---|
| 0–24″ | 7·0 |
| 24–30″ | 7·0–8·0 |
| 30–48″ | 7·0–8·0 |

214S—Loxley Series.

| | pH. |
|---|---|
| 0–16″ | 7·0 |
| 16–18″ | 7·0 |
| 18–19″ | 7·0 |
| 19–40″ | 7·0–8·0 |
| 40–50″ | 7·0–8·0 |

221S—Loxley Series.

| | pH. |
|---|---|
| 0–3″ | 7·0 |
| 3–18″ | 7·0 |
| 18–24″ | 7·0–8·0 |
| 24–30″ | 7·0–8·0 |

222S—Coxley Series B.

| | pH. |
|---|---|
| 0–8″ | 7·0–8·0 |
| 8–18″ | 7·0–8·0 |
| 18″ | 7·0–8·0 |

235S—Coxley Series C.

| | pH. |
|---|---|
| 0–9″ | 7·0–8·0 |
| 9–18″ | 7·0–8·0 |
| 18–30″ | 7·0–8·0 |
| 30–42″ | 7·0–8·0 |
| 42–54″ | 7·0–8·0 |

234S—Coxley Series D.

| | pH. |
|---|---|
| 0–3″ | 7·0 |
| 3–11″ | 7·0 |
| 11–18″ | 7·0–8·0 |
| 18–32″ | 7·0–8·0 |
| 32–42″ | 7·0–8·0 |
| 42–54″ | 7·0–8·0 |

TABLE II.—*Continued.*

252S—Coxley Series B.

| | pH. |
|---|---|
| 0–6″ | 7·0–8·0 |
| 6–14″ | 7·0–8·0 |
| 14″ | 7·0–8·0 |

45W—Barnston Series.

| | pH. |
|---|---|
| 1″ | 6·0 |
| 8″ | 6·0–7·0 |
| 14″ | 6·0–7·0 |
| 19″ | 6·0–7·0 |
| 34″ | 7·0 |
| 54″ | 7·0–8·0 |

74W—Clatterbridge Series.

| | pH. |
|---|---|
| 1″ | 6·0–7·0 |
| 8″ | 6·0–7·0 |
| 9″ | 7·0 |
| 18″ | 7·0–8·0 |
| 36″ | 7·0–8·0 |
| 54″ | 8·0 |

68W—Brimstage Series.

| | pH. |
|---|---|
| 1″ | 6·0–7·0 |
| 8″ | 7·0 |
| 12″ | 7·0 |
| 24″ | 7·0 |
| 34″ | 7·0 |
| 40″ | 7·0–8·0 |

30W—Haddon Series.

| | pH. |
|---|---|
| 1″ | 6·0 |
| 8″ | 6·0 |
| 18″ | 6·0 |
| 36″ | 7·0 |
| 54″ | 7·0–8·0 |

21W—Ness Series.

| | pH. |
|---|---|
| 0–8″ | 7·25 |
| 8–16″ | 7·25 |
| 16–24″ | 7·25 |
| 24–27″ | 7·25 |

85W—Ness Series.

| | pH. |
|---|---|
| 0–8″ | 5·75 |
| 8–16″ | 7·25 |
| 16–21″ | 6·50 |
| 21–23″ | 6·50 |

60W—Clatterbridge Series.

| | pH. |
|---|---|
| 0–8″ | 6·00 |
| 8–16″ | 6·25 |
| 16–19″ | 7·00 |
| 19–28″ | 7·50 |
| 28–35″ | 7·25 |

TABLE II.—*Continued.*

30W—Haddon Series.

| | pH. |
|---|---|
| 0–8″ | 5·75 |
| 8–12″ | 6·00 |
| 12–21″ | 6·50 |
| 21–40″ | 7·50 |

105W—Hough Series.

| | pH. |
|---|---|
| 0–8″ | 5·50 |
| 8–16″ | 5·75 |
| 16–24″ | 6·25 |

83W—Irby Series.

| | pH. |
|---|---|
| 0–2½″ | 5·75 |
| 2½–11″ | 5·75 |
| 11–18″ | 6·25 |
| 18–30″ | 7·25 |
| 30–50″ | 8·00 |
| 50–52″ | 8·00 |

79W—Haddon Series.

| | pH. |
|---|---|
| 0–6″ | 5·00 |
| 6–12″ | 5·00 |
| 12–17″ | 5·50 |
| 17–18″ | 5·0 |

76W—Frankby Series.

| | pH. |
|---|---|
| 0–8″ | 6·25 |
| 8–13″ | 6·50 |
| 13–15″ | 7·00 |

24W—Haddon Series.

| | pH. |
|---|---|
| 0–3″ | 5·00 |
| 3–9″ | 4·50 |
| 9–15″ | 5·50 |
| 15″ | 5·00 |

## SUMMARY OF RESULTS.

A. The Alluvial soils of the region of Somerset studied may be divided into five groups :—

I. Humous sub-aqueous group. Here there is a very simple profile with calcium carbonate concretions in some cases, and the water-table is always high. Widely distributed.

II. Typical Glei soils ; free from carbonates.

III. Warp soils with a Glei structure also.

IV. Thin humous peat with different degrees of decomposition, overlying blue calcareous clay.

V. Altered Glei soil, due to changes of water-table ; covering a wide area.

They are all Ectodynamomorphic soils in Glinka's classification, belonging to Ramann's Humid group ; they are azonal soils.

B. On some deposits of sand in the middle of the Somerset moorland, the podsol is developed. This is the zonal soil of Sibirtzev ; it is also an Ectodynamomorphic soil.

C. The other soils studied in Somerset are on calcareous material. They appear to fall into two types :—

I. The Rendzina, because they have a high calcium carbonate content in the surface horizon and the greyish-brown colour and an alkaline reaction. These are developed on the Lower Lias limestone and Trias red marl.

II. The Terra Rossa, having a slightly acid reaction, with brown to reddish-brown colour. On slopes, the colour is frequently quite a brilliant red. The soil is completely leached of calcium carbonate. The Terra Rossa is developed on hard grey Carboniferous limestone.

Both these are Endodynamomorphic soils in Glinka's classification, and belong to the Humid group of Ramann, being in some cases Brown Earths (Rendzina modification) and in others Red Earths. They are Intrazonal soils.

D. The soils developed on the Carboniferous limestone in Derbyshire differ from those in Somerset in the colour profile. Shallow soils are found which are quite black (Wheeldon Series). The calcium carbonate content of these shallow soils seems to be due to fragments of the disintegrating limestone. The other series are completely leached of calcium carbonate. In colour they are usually brown, with a faint reddish tint in some. They do not resemble the Terra Rossa ; the colder climate, the higher altitude being included in this factor, is probably the reason. They have also probably been subjected to glaciation whereas those in the Mendips have not. They resemble more the typical Brown Earths of Ramann. Probably climate is a more important factor here than in Somerset in determining the soil type. It is, however, an Endodynamomorphic soil.

E. The soils in the Cheshire region are either podsols or show signs of podsolization. A number of series have been identified, but it is suggested that they are podsols modified owing to the work of man. The natural soil of the district is the humous podsol, and is found in pine woods. The parent material is either a sandstone or boulder clay in all the soils studied. They belong to the zonal group of Sibirtzev, and the Ectodynamomorphic group of Glinka.

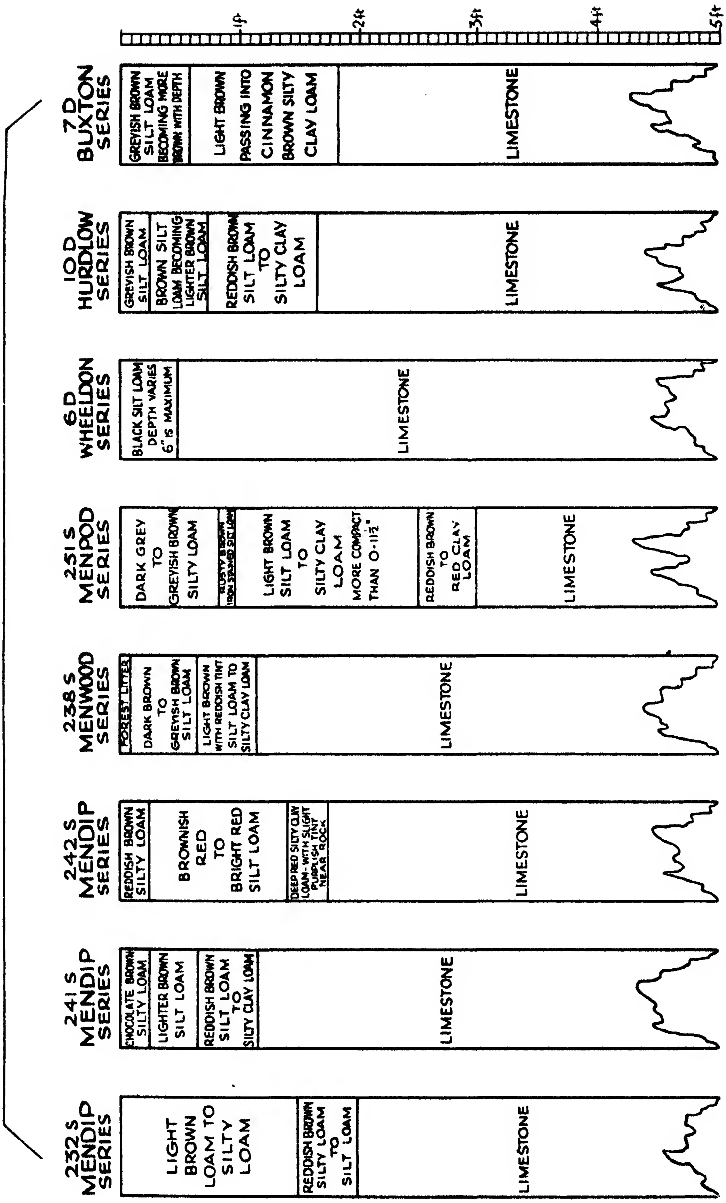
F. Parent material is the dominant factor in the soils studied. However, the same parent material does give slightly different soils when the climate is not the same ; this is illustrated by the soils on the Carboniferous limestone of Derbyshire and Somerset.

G. The soils in the areas studied have been assigned as far as possible to the places to which they belong in the three chief classifications in use. (These classifications appear to the author to be largely complementary.)

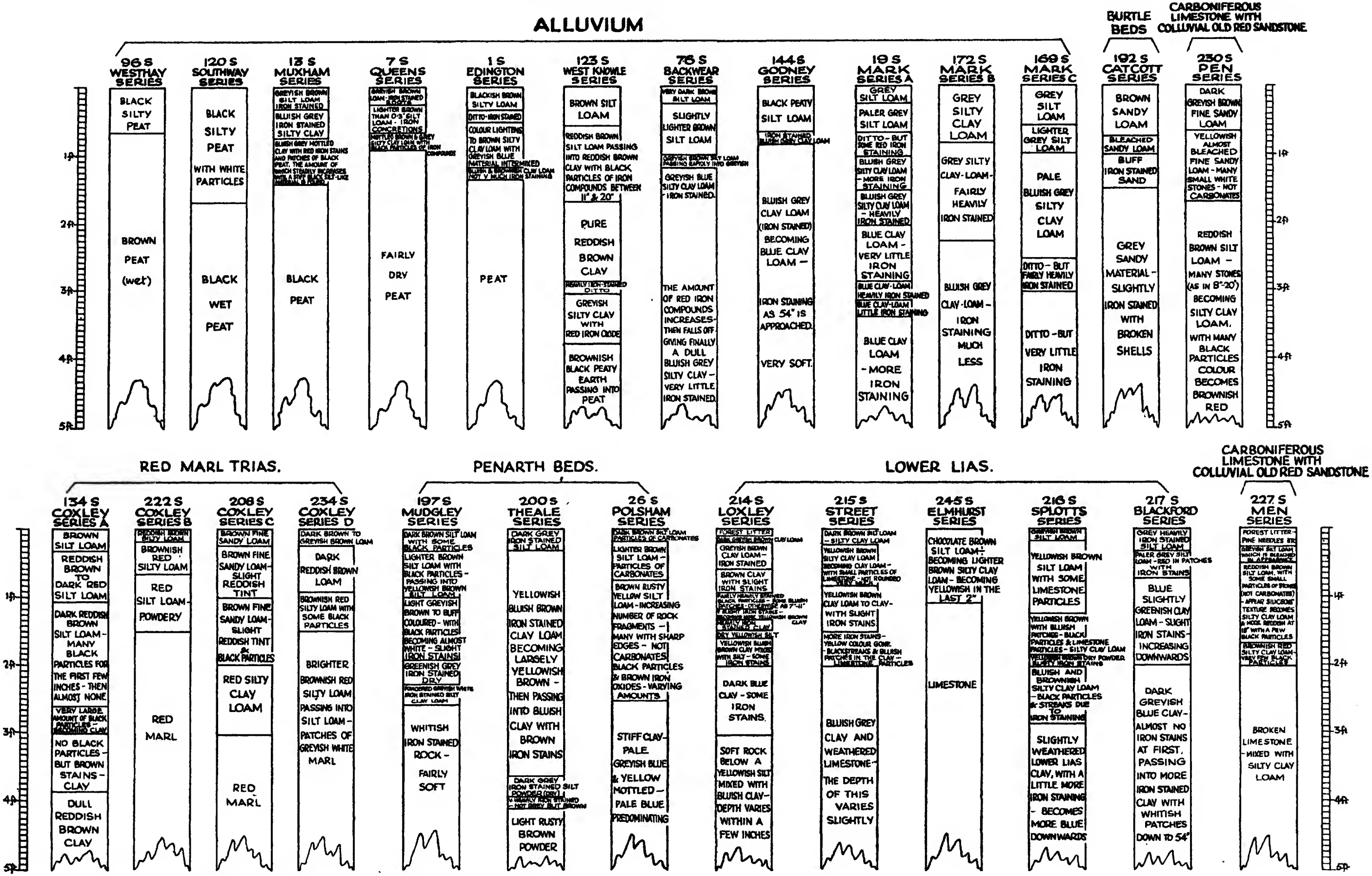
H. The use of the terms Endodynamomorphic and Ectodynamomorphic with the soils studied is open to objection. In Somerset, calcareous material gives rise to Brown Earths and sandstone to podsol. The parent material seems to decide the soil type although we have called one Endodynamomorphic and the other Ectodynamomorphic. It seems quite possible that the English soils are not clearly Endodynamomorphic or Ectodynamomorphic, but that there is a compromise, the Endodynamomorphic factor being probably the more important.

DIAGRAMS OF SOIL PROFILES IN DERBYSHIRE AND SOMERSET

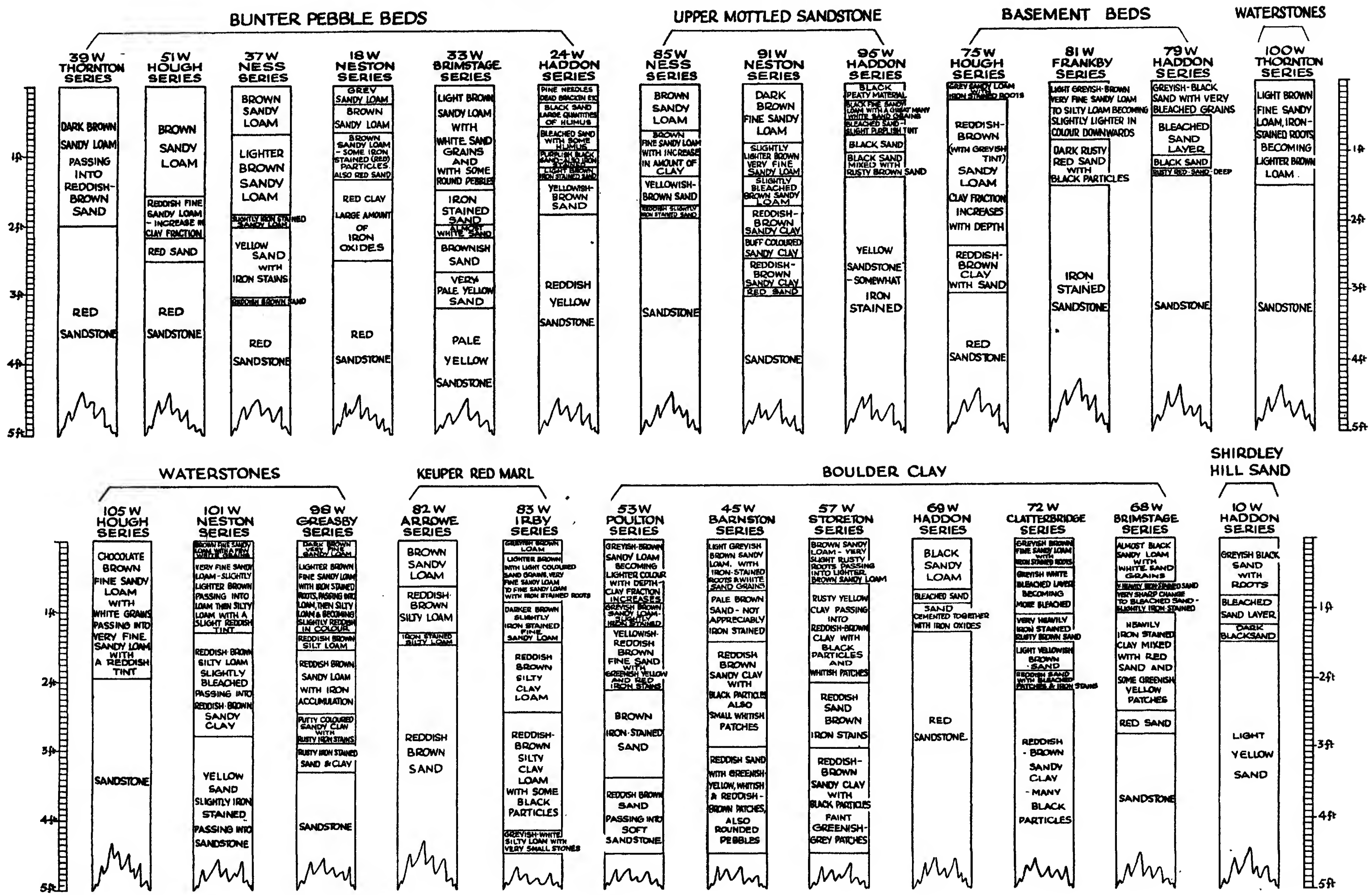
CARBONIFEROUS LIMESTONE



DIAGRAMS OF SOIL PROFILES IN SOMERSET



# DIAGRAMS OF SOIL PROFILES IN CHESHIRE



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# NOTES ON MYRIAPODA XXXV. NOMENCLATURAL SOURCES

By the REV. S. GRAHAM BRADE-BIRKS, D.Sc.(London), M.Sc.(Manchester),

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AN attempt is here made to give indications, gathered from many sources, of the original descriptions of the forms of Symphyla, Diplopoda, Pauropoda, and Chilopoda known to occur in the British Isles. Published occurrences which appear to the writer to be correct are shown for England, Ireland, and Scotland, by the addition of the initial letters of the names of those countries. A few published Welsh occurrences are indicated by the use of the initial letter W. Some of the synonyms which appear to be important are added, and there are some other occasional notes which may be of service.

I am indebted to many kind helpers in the gathering of the information in this paper. Dr. R. A. Bagnall's valuable check-list (1918, *Journ. Zool. Res.*, **3**, pp. 90-3) paved the way, my wife has given me help in a number of cases, and I am also indebted to Dr. C. Davies Sherborn, M. Henry W. Brölemann, and Dr. R. V. Chamberlin for valuable assistance. To these and others who have been kind enough to forward the work I express my best thanks.

Class **SYMPHYLA**
Ryder, 1880, Amer. Naturalist, **14**, p. 375.

Family SCOLOPENDRELLIDAE Newport, 1844, Trans. Linn. Soc. Lond., **19**, p. 373.

Sub-Family *SCUTIGERELLINAE* Bagnall, 1913, Journ. Linn. Soc. Lond., **32**, pp. 196-7.

SCUTIGERELLA Ryder, 1882, Proc. U.S. Nat. Mus., **5**, p. 234.

*Scutigerella immaculata* (Newport, 1884). Syn: 1844, *Scolopendrella immaculata* Newport, Trans. Linn. Soc. Lond., **19**, p. 374, Tab. 40, fig. 4. E.I.S.W.

*Scutigerella spinipes* Bagnall, 1911, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 24-6, fig. 2. E.I.S.W.

*Scutigerella biscutata* Bagnall, 1911, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 26-8, pl. 1, figs. 3-6. E.I.S.

NEOSCUTIGERELLA Bagnall, 1913, Journ. Linn. Soc. Lond., **32**, pp. 196-7.

*Neoscutigerella hanseni* (Bagnall, 1911). Syn: 1911, *Scutigerella hanseni* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 28-30, fig. 4, pl. 1, figs. 7-9. E.

HANSENIELLA Bagnall, 1913, Journ. Linn. Soc. Lond., **32**, pp. 196-7.

*Hanseniella caldaria* (Hansen, 1903). Syn: 1903, *Scutigerella caldaria* Hansen, Q.J. Micro. Sci., **47**, pp. 36-8, pl. 2, figs. 3a-3g. E.S.

Sub-Family *SCOLOPENDRELLINAE* Bagnall, 1913, Journ. Linn. Soc. Lond., **32**, pp. 196 and 198.

SCOLOPENDRELLA Gervais, 1839, Comptes rendus de l'Acad. d. sciences, **9**, p. 532.

*Scolopendrella notacantha* Gervais, 1839, Comptes rendus de l'Acad. d. sciences, **9**, p. 532. W.

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Syn: 1903, *Scolopendrella subnuda* Hansen, Q.J. Micros. Sci., **47**, pp. 70-2, pl. 6, figs. 2a-2g.
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Syn: 1886, *Scolopendrella isabellae* Grassi, Mem. d. Reale Ac. d. Sci. d. Torino, ser. 2, **37**, pp. 594-5. E.

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Syn: 1911, *Scolopendrella isabellae* Grassi var. *dunelmensis* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, p. 33.
1912, *Scolopendrella dunelmensis* Bagnall, ibid., p. 174. E.

*Symphylella jacksoni* (Bagnall, 1912).
Syn: 1912, *Scolopendrella jacksoni* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, p. 175, fig. 1. W.

*Symphylella vulgaris* (Hansen, 1903).
Syn: 1903, *Scolopendrella vulgaris* Hansen, Q.J. Micros. Sci., **47**, pp. 79-81, pl. 6, figs. 6a-6d, pl. 7, fig. 1a. E.I.S.

*Symphylella horrida* (Bagnall, 1911).
Syn: 1911, *Scolopendrella horrida* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 34-5, pl. 1, figs. 21-2. E.W.

*Symphylella delicatula* (Bagnall, 1911).
Syn: 1911, *Scolopendrella delicatula* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 36-7, pl. 1, figs. 23-4. E.I.S.

*Symphylella minutissima* (Bagnall, 1911).
Syn: 1911, *Scolopendrella minutissima* Bagnall, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, pp. 38-9, pl. 1, figs. 25-7. E.S.

## Class **DIPLOPODA**

Blainville-Gervais, 1844, Ann. d. sci. nat. 3, sér. **2**, p. 51.

Sub-Class **PSELAPHOGNATHA** Latzel, 1884, Die Myr. der öst.-ung. Mon. **2**, p. 69.

Family POLYXENIDAE Gray et Jones, 1842, Todd, Cyclop. of Anat. & Phys., **3**, p. 546.

POLYXENUS Latreille, 1802, Hist. nat. d. Crust. et d. Ins., **3**, p. 45.

*Polyxenus lagurus* (Linné, 1758).
Syn: 1758, *Scolopendra lagura* Linné, Syst. nat. (ed. x.), p. 637. E.I.S.

Sub-Class **CHILOGNATHA** Latreille, ex p., 1802, Hist. nat. d. Crust. et d. Ins., **3**, p. 44.

Order ONISCOMORPHA Pocock, 1887, Ann. & Mag. N. Hist. (v.), **20**, p. 293.

Family GLOMERIDAE Leach, 1814, Trans. Linn. Soc. Lond., **11**, p. 376.

GLOMERIS Latreille, 1802, Hist. nat. d. Crust. et d. Ins., **3**, p. 44.

*Glomeris marginata* (Villers, 1789).
Syn : 1789, *Oniscus marginatus* Villers, Linn. Ent., **4**, 187. E.I.S.

*Glomeris marginata* var. *perplexa* (Latzel, 1895).
Syn : 1895, *Glomeris perplexa* Latzel, Beiheft z. Jahresb. d. Hamburg. wiss. Anst., **12**, p. 107. E.S.
Bagnall regards this animal as a distinct species.

Order PROTEROSPERMOPHORA Verhoeff, 1900, Zool. Jahrb. Syst., **13**, pp. 52-4.

Family POLYDESMIDAE Leach, ex p., 1814, Trans. Linn. Soc. Lond., **11**, p. 381.

BRACHYDESMUS Heller, 1857, Sitzgsb. d. k. Ak. d. Wiss., Wien, **26**, p. 318.

*Brachydesmus superus* Latzel, 1884, Die Myr. der öst.-ung. Mon., **2**, p. 130.

*Brachydesmus superus mosellanus* Verhoeff, 1891, Berl. ent. Zeits., **36**, p. 125, Taf. v., fig. 7. E.I.S.*

POLYDESMUS Latreille, 1802, Hist. nat. d. Crust. et d. Ins., **3**, p. 44.

*Polydesmus angustus* Latzel, 1884.
Syn : 1884, *Polydesmus complanatus* var. *angustus* Latzel, Bull. Soc. Amis. Sc-nat., Rouen (1883) (2), **19**, p. 267. E.I.S.
*Polydesmus complanatus* (Linné, 1761), Syn : 1761, *Iulus complanatus* Linné, Fauna succ. (ed. **2**), p. 502, is a different animal altogether, but the name *Polydesmus complanatus* has been widely used in British and other records for *Polydesmus angustus* Latzel.

*Polydesmus edentulus* C. L. Koch, 1847, Syst. d. Myr., p. 134. I.

*Polydesmus testaceus* C. L. Koch, 1847, Syst. d. Myr., 135.
Syn : 1884, *Polydesmus subinteger* Latzel, Bull. Soc. Amis. Sc-nat., Rouen (1883) (2), **19**, p. 269. E.

* Almost certainly.

*Polydesmus coriaceus* Porath, 1870, Öfvers Vetensk. Akad. Förhandl., **27**, p. 819.
Syn : 1884, *Polydesmus inconstans* Latzel, Bull. Soc. Amis. Sc-nat., Rouen (1883) (2), **19**, p. 269, fig. E.I.S.

*Polydesmus gallicus* Latzel, 1884, Bull. Soc. Amis. Sc-nat., Rouen, p. 269, fig. E.I.

*Polydesmus denticulatus* C. L. Koch, 1847, Syst. d. Myr., p. 135. E.I.S.

Family MASTIGONODESMIDAE Attems, 1914.

EUMASTIGONODESMUS Brölemann, 1915, Bull. de la Soc. d'Hist. Nat. de l'Afrique du Nord, **7** ann, No. 6, 15 June 1915, p. 93.

*Eumastigonodesmus boncii* (Brölemann, 1908).
Syn : 1908, *Mastigonodesmus boncii* Brölemann, Bull. Soc. ent. de France, 1908, No. 9, pp. 171-3. E.

Family STRONGYLOSOMIDAE Cook, 1894.
Syn : 1894, *Strongylosomatidae* Cook, P.U.S. Mus., **18**, p. 82.

MACROSTERNODESMUS Brölemann, 1908, Bull. Soc. ent. de France, p. 94.
Syn : 1910, *Titanosoma* Verhoeff, Zool. Anz., **36**, p. 137.

*Macrosternodesmus palicola* Brölemann, 1908, Bull. Soc. ent. de France, pp. 94-6, figs. 1 and 2.
Syn : 1910, *Titansoma jurassicum* Verhoeff, Zool. Anz., **36**, p. 143, figs. 6-9. E.S.

OPHIODESMUS Cook, 1895, Ann. N. York Ac., **9**, p. 5.

*Ophiodesmus albonanus* (Latzel, 1895).
Syn : 1895, *Paradesmus albonanus* Latzel, Beiheft z. Jahresb. d. Hamburg, wiss Anst., **12**, circa p. 107.

1895, *Strongylosomum verhoeffi* Brölemann, Feuille des Jeunes Nat., **3** sér. 25 ann., No. 298, pp. 147-8, fig. E.

PARADESMUS Saussure, 1859, Linn., ent., **13,** p. 325 (not pre-occupied by plant genus).
Non-syn : 1835, *Paradesmus* Corda.
Syn : 1893, *Orthomorpha* Bollman, Bull. U.S. Mus., **46,** p. 159.
Bollman established *Orthomorpha* on the assumption that *Paradesmus* was pre-occupied by *Paradesmus* Corda, 1835, in de Carro, Essay on the Mineral Waters of Carlsbad . . . (Prague), 1835, p. 123, pl. 4, fig. 47, but this generic name is applied to a primitive plant and consequently *Paradesmus* is not pre-occupied zoologically by Corda's genus.

*Paradesmus gracilis* (C. L. Koch, 1847).
Syn : 1847, *Fontaria gracilis* C. L. Koch, Syst. d. Myr., p. 142. E.I.S.

*Paradesmus coarctatus* (Saussure, 1860).
Syn : 1860, *Polydesmus coarctatus* Saussure, Mém. Mex. Myr., p. 39, fig. 18. E.

STRONGYLOSOMA Brandt, 1833, Bull. Soc. Nat., Moscow, **6,** p. 205.
I have regarded here as a synonym *Stosatea* Gray and Jones, 1842 or 1843, Todd, Cyclop. of Anat. & Phys., **3,** p. 546, *char. emend.* Brölemann, 1916.

*Strongylosoma italicum* Latzel, 1886. (Diagnosi di specie e varietà nuove di Miriapodi raccolti in Liguria dal Dott. G. Caneva), Bull. Ent., Ital., **18,** pp. 308-9. E.

Order ASCOSPERMOPHORA Verhoeff, 1900, Zool. Jahrb. Syst., **13,** pp. 52-4.

Family CHORDEUMIDAE C. L. Koch, 1847, Syst. d. Myr., pp. 49 et 119, *char. emend.* Verhoeff, 1909, Zool. Anz., **34,** p. 566-72.

Sub-Family *MICROCHORDEUMINAE* Verhoeff, 1910, Stuttgart Jahreshefte Ver. Natk., **66,** p. 379.

CHORDEUMELLA (Verhoeff, 1897.)
Syn : 1897, *Microchordeuma* (*Chordeumella*) Verhoeff, Arch. Naturg. Jahrg. 63, Bd. **1**, Heft 2, p. 151, pl. xiv., figs. 4 and 6.

*Chordeumella scutellare* Ribaut, 1913, Bull. Soc. d'Hist. Nat. d. Toulouse, **45,** pp. 93-6, figs. 1-9.

*Chordeumella scutellare bagnalli* Brade-Birks, 1918, Ann. & Mag. Nat. Hist. (ix.), **2,** pp. 335-6, figs. 2 and 3. E.

*Chordeumella scutellare brölemanni* Brade-Birks, 1916. Lancs. & Ches. Nat., **9,** pp. 49-54, pls. 1 and 2, figs. 1-8. E.

Family BRACHYCHAETEUMIDAE Verhoeff, 1911, Zool. Anz., **38,** p. 456, *char. emend.* Brade-Birks, 1918, J. Zool. Res., **3,** p. 48.

BRACHYCHAETEUMA Verhoeff, 1911, Zool. Anz., **38,** p. 456-7, *char. emend.* Brade-Birks, 1918, J. Zool. Res., **3,** pp. 48-50.
Syn : 1917, *Iacksoneuma* Brade-Birks, J. Zool. Res., **2,** pp. 135-8.

*Brachychaeteuma bagnalli* Verhoeff, 1911, Zool. Anz., **38,** pp. 457-8, *char. emend.* Brade-Birks, 1918, J. Zool. Res., **3,** pp. 50-3, figs. 1-4. E.

*Brachychaeteuma bradeae* (Brölemann et Brade-Birks, 1917).
Syn : 1917, *Iacksoneuma bradeae* Brölemann et Brade-Birks, J. Zool. Res., **2,** pp. 138-48, figs. 1-21. E.

*Brachychaeteuma melanops* Brade-Birks, 1918, J. Zool. Res., **3,** pp. 55-61, figs. 1-6. E.

*Brachychaeteuma quartum* Brade-Birks, 1918, Ann. & Mag. Nat. Hist. (ix.), **2,** pp. 333-4, fig. 1. E.

Family CRASPEDOSOMIDAE (Jones et Gray, 1842), *char. emend.* Verhoeff, 1909, Zool. Anz., **34,** p. 566-72.

Syn : 1842, *Craspedosomadae* Jones et Gray, in Todd's Cyclop. of Anat. & Phys., **3,** p. 546.

CRASPEDOSOMA Leach et Rawlins, 1814, Trans. Linn. Soc. Lond., **9,** pt. 2, p. 380.

*Craspedosoma rawlinsi* Leach, 1814, Trans. Linn. Soc. Lond., **11,** pt. 2, p. 380.

Syn : 1891, *Craspedosoma rawlinsi* var. *simile* Verhoeff, Berl. ent. Zeits., **36,** pp. 128-30.

1910, *Craspedosoma simile* Verhoeff, S.B. Ges. nat. Freunde, No. **1,** pp. 19-62, figs. 3-9.

Non-syn : 1884, *Craspedosoma rawlinsi* Leach, of Latzel, die Myr. d. öst.-ung. Mon., **2,** pp. 191-4, Taf. viii., figs. 92 and 93.

Non-syn : 1895, *Craspedosoma simile* Attems, Sitzungsb. k. Akad. Wiss., Wien, pp. 191-2, Taf. ii. figs. 33-39a, Taf. iv., fig. 53. E.I.S.

*Craspedosoma rawlinsi* var. *rhenanum* (Verhoeff, 1910).

Syn : 1910. *Craspedosoma simile* subsp. *rhenanum* Verhoeff, Berlin Sitzber Ges. natf. Freunde, 1910. E.

Bagnall (1913, V. Derwent Trans., 99-158), on page 34 of his reprint, under " *C. simile* (Verhoeff) " includes this note : " Gibside, 1912, together with the subspecies *rhenanum*." In view of such a record it is impossible to accept the name *rhenanum* as that of a true subspecies (in the sense of a distinct race geographically separated from the race of forms typical of the species). We must, therefore, regard *rhenanum* as a variety of *C. rawlinsi*, and *balticum* and *bagnalli*, which Verhoeff gives as varieties of his subspecies *rhenanum*, must be regarded either as varieties of *C. rawlinsi* or as of still lower rank. Here I am regarding them as varieties.

*Craspedosoma rawlinsi* var. *bagnalli* (Verhoeff, 1916).

Syn : 1916, *Craspedosoma simile rhenanum* var. *bagnalli* Verhoeff, Zool. Jahrb., **39,** p. 350. E.

*Craspedosoma rawlinsi* var. *balticum* (Verhoeff, 1910, Nova Acta).

Syn : 1912, *Craspedosoma rawlinsi rhenanum* var. *balticum* Verhoeff, Zool. Anz., **39,** p. 504. E.

POLYMICRODON Verhoeff, 1897, Arch. f. Naturg., **63,** p. 137.

Syn : 1895, *Grypogona* (? for *Gryphogona*) Cook and Collins, Ann. N. Yk. Ac., **9,** p. 3.

*Polymicrodon polydesmoides* (Leach, 1817).

Syn : 1817, *Craspedosoma polydesmoides* Leach, Zool. Misc., **3,** p. 36, *t.* 134, figs. 6-9.

1891, *Atractosoma latzeli* Verhoeff, Berl. Ent. Zeits., **36,** pp. 127-8, pl. v., figs. 4-6.

1895, *Atractosoma latzeli gallicum* Verhoeff, Zool. Anz., **18,** pp. 220-1.

1896, *Craspedosoma latzeli gallicum* Verhoeff, Arch. f. Naturg., **62,** p. 241.

1897, *Polymicrodon latzeli gallicum* Verhoeff, Arch. f. Naturg., **63,** p. 137. E.I.S.

Order OPISTHOSPERMOPHORA Verhoeff, 1900, Zool. Jahrb. Syst., **13,** pp. 52-4.

Family BLANIULIDAE Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60,** p. 1.

Syn : 1847, *Blaniuliden* C. L. Koch, Syst. d. Myr., p. 48 (116).

1895, *Blanjulidae* Sinclair, Camb. Nat. Hist., **5,** p. 44.

1911, *Protoiulidae* Verhoeff, Zool. Anz., **38,** p. 536 (as sub-family *Protoiulinae* Verhoeff, 1909, Zool. Anz., **34,** p. 475).

ARCHIBOREOIULUS Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60,** p. 9.

*Archiboreoiulus pallidus* (S. G. Brade-Birks, 1920).
Syn: 1920, *Proteroiulus pallidus* S. G. Brade-Birks, Ann. Mag. Nat. Hist. (ix.), **6**, p. 364. E.

Sub-Family *BLANIULINAE* Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 2.
Syn: 1909, *Blaniulini* Verhoeff, Zool. Anz., **34**, p. 475.
1911, *Blaniulinae* Verhoeff, Zool. Anz., **38**, pp. 536-7.

Tribe **Blaniulini** Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 6.
Syn: 1909, *Blaniulini* Verhoeff, Zool. Anz., **34**, p. 475 (and ? earlier) ex p.

BLANIULUS Gervais, 1836, Bull. Soc. Phil., Paris, p. 72.

*Blaniulus guttulatus* (Bosc, 1792).
Syn: 1792, *Iulus guttulatus* Bosc, Bull. d. l. Soc. Phil., Paris, p. 12.
1814, *Iulus pulchellus* Leach, Trans. Linn. Soc. Lond., **11**, p. 379. E.I.S.

Tribe **Boreoiulini** Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 9.

BOREOIULUS Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 9.

*Boreoiulus tenuis* (Bigler, 1913).
Syn: 1913, *Monacobates tenuis* Bigler, Rev. Suisse Zool., Geneva, **21**, p. 750, figs. E.S.

Tribe **Choneiulini** Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 4.

CHONEIULUS Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 4.

*Choneiulus palmatus* (Němec, 1895).
Syn: 1895, *Blaniulus palmatus* Němec, Práce z. ústavu pro zoologii a srovnávacé anatomii c. K. ceské univ. v. Praze. 1899, *Typhloblaniulus verhoeffi* Attems, Zool. Jahrbuch Syst., **12**, p. 330, pl. xvi., figs. 61-5. E.

Tribe **Nopoiulini** Verhoeff, 1911, Zool. Anz., **38**, p. 538. Brölemann, 1921, Arch. Zool. exper. gèn. (notes and revues), **60**, p. 10.

NOPOIULUS Menge, 1851, Neueste Schr. d. naturf. Ges. Danzig, **4**, p. 7.

*Nopoiulus minutus* (Brandt, 1841).
Syn: 1841, *Julus minutus* Brandt, Recueil, p. 89 (see Chamberlin, 1921, Proc. Biol. Soc., Washington, **34**, pp. 83-4).
Syn: 1847, *Iulus Kochi* Gervais, Hist. nat. d. Ins. Apt., **4**, p. 145.
1838, *Iulus pulchellus* C. L. Koch, Deutschl. Crust. Myr., etc., Heft **22**, Tab. 13.
1868, *Blaniulus venustus* Meinert, Naturh. Tidsskr., 3 R., **5**, p. 20.
Non-syn: 1814, *Iulus pulchellus* Leach, Trans. Linn. Soc. Lond., **11**, p. 379. E.I.

PROTEROIULUS Silvestri, 1897, Bull. Soc. Ent., Ital., **29**, p. 24.
Syn: 1911, *Amsteinia* Verhoeff, Zool. Anz., **38**, p. 539.

*Proteroiulus fuscus* (Am Stein, 1857).
Syn: 1857, *Blaniulus fuscus* Am Stein, Jahresber. d. naturf. Gesellsch. Graubündens, Neue Folge, p. 139. E.I.S.

Sub-Family *ISOBATINAE* Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, pp. 1-2.
Syn: 1909, *Isobatini** Verhoeff, Zool. Anz., **34**, p. 475.
1911, *Isobatinae* Verhoeff, Zool. Anz., **38**, p. 537.

Tribe **Isobatini** (Verhoeff, 1909) Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 2.
Syn: 1909, Verhoeff, Zool. Anz., **34**, p. 475 (and ? earlier) ex p.

* Tribe of Sub-Family *Protoiulinae* Verhoeff.

Sub-Tribe **Isobatina** Brölemann, 1921, Arch. Zool. exper. gèn. (notes et revues), **60**, p. 2.

ISOBATES Menge, 1851, Neueste Schr. d. naturf. Ges., Danzig, **4**, p. 6.

Sub-Genus THALASSISOBATES Verhoeff, 1908, Zool. Anz., **32**, p. 488.

*Isobates* (*Thalassisobates*) *littoralis* Silvestri, 1903, in Berlese Acari, Myr., etc., fasc. **99**. E.

Sub-Genus ISOBATES (s. str. Brölemann, 1921), Menge, 1851, Neueste Schr. d. naturf. Ges., Danzig, **4**, p. 6.

*Isobates varicornis* (C. L. Koch, 1847).
Syn: 1847, *Nemasoma varicorne* C. L. Koch, Syst. d. Myr., p. 116. E.I.S.

Family SPIROBOLIDAE Bollman, 1893, The Myr. of N. Amer., Bull., U.S. Nat. Mus., No. 46.

TRIGONIULUS Pocock, 1894, in Max Weber's Zool. Erg. ein Reis. Niederl., Ost-Indien, **3**.

*Trigoniulus goësi* (Porat, ? 1872).
Syn: ? 1872, *Spirobolus goësii* Porat, ? Oefvers, K. Vet.-Akad. Förhandl., No. 5. E.

Family IULIDAE Leach, ex p., 1814, Trans. Linn. Soc. Lond., **11**, p. 376.

IULUS Linné, 1758, Syst. nat., ed. x., **1**, p. 639.

Sub-Genus MICROPODOIULUS Verhoeff, 1893, Zool. Anz., **16**, p. 480.

*Iulus* (*Micropodoiulus*) *scandinavius* (Latzel, 1884).
Syn: 1884, *Iulus scandinavius* Latzel Die Myr. d. öst-ung. Mon., **2**, pp. 322-5.
1891, *Iulus ligulifer* Latzel-Verhoeff, Berl. ent. Zeits., **36**, p. 152. E.I.S.

LEPTOIULUS Verhoeff, 1893, Zool. Anz., **16**. Verhoeff, 1895, Verh. Ges., Wien, **44**, p. 152.

*Leptoiulus belgicus* (Latzel, 1884).
1884, *Julus belgicus* Latzel, C. R. ent. Belg. (3), **48**, p. ccxlix., fig. E.

OPHYIULUS Berlese, 1884, Acari, Myr., etc., fasc. **12**.
Syn: 1886, *Ophiulus* Iulidi d. Mus. di Firenze.

*Ophyiulus pilosus* (Newport, 1842).
Syn: 1842, *Iulus pilosus* Newport, Proc. Zoo. Soc., Lond., **10**. 1842, Ann. Mag. N. Hist., **11**, p. 316.
1847, *Iulus longabo* C. L. Koch, Syst. d. Myr., p. 113.
1868, *Iulus fallax* Meinert, Naturh. Tidsskr., **3** R., **5**, p. 15. E.I.S.

BRACHYIULUS Berlese (1884, Acari, Myr., etc., fasc. **12**), 1886, Bull. Soc. Ent., Ital., **18**.
Syn: 1884, *Iulus* (*Brachyiulus*) Berlese, Acari, Myr., etc., fasc. **12**, *char. emend.* Verhoeff, 1894.

Sub-Genus MICROBRACHYIULUS Verhoeff, 1897, Zool. Anz., **20**, p. 114.

*Brachyiulus* (*Microbrachyiulus*) *pusillus* (Leach, 1814).
Syn: 1814, *Iulus pusillus* Leach, Trans. Linn. Soc. Lond., **11**, p. 379. *B.* (*M.*) *littoralis* Verhoeff. E.I.S.

SCHIZOPHYLLUM Verhoeff, 1895, Zool. Anz., **18**, p. 224.
Non-Syn: 1873, *Archiulus* Scudder, Mem. Boston Soc. Nat. Hist., **2**. (This is a fossil genus.)

*Schizophyllum sabulosum* (Linné, 1758).
Syn: 1758, *Iulus sabulosus* Linné, Syst. nat. (ed. x.), **1**, p. 640. E.I.S.

TACHYPODOIULUS Verhoeff, 1893, Zool. Anz., **16**, p. 480.

*Tachypodoiulus niger* (Leach, 1817).
Syn: 1817, *Iulus niger* Leach, Zool. Misc., **3**, 34.
1838, *Iulus albipes* C. L. Koch, Deutschl. Crust. Myr., etc., Heft **22**, Taf. 10.
1857, *Iulus transversosulcatus* Am Stein, Myr. u. Crust. Graubündens, p. 137. E.I.S.

CYLINDROIULUS Verhoeff, 1894, as sub-genus (1899 as genus), Verh. Ges., Wien, **44**, p. 151.
Syn: 1894, *Iulus* (*Cylindroiulus*) Verhoeff, Verh. Ges., Wien, **44**, p. 151.
? 1883, *Iulus* (*Diploiulus*), Berlese Acari Myr., etc., fasc. **8**.

*Cylindroiulus parisiorum* (Brölemann et Verhoeff, 1896).
Syn: 1896, *Iulus* (*Anoploiulus*) *parisiorum* Brölemann et Verhoeff, Feuille des Jeunes Nat., No. **311**, pp. 214-15, figs. 1-6. E.

*Cylindroiulus punctatus* (Leach, 1817).
Syn: 1817, *Iulus punctatus* Leach (*nec* Say), Zool. Misc., **3**, p. 34.
1868, *Iulus silvarum* Meinert Naturh. Tidsskr., **3** R., **5**, p. 13.
? 1884, *Iulus luridus* var. *gracilis* Latzel in Gadeau de Kerville Myr. d. Normandie Ire liste Rouen, 1884, p. 17. E.I.S.

*Cylindroiulus londinensis* (Leach, 1815).
Syn: 1815, *Iulus londinensis* Leach, Trans. Linn. Soc. Lond., **11**, p. 378.
1886, *Iulus psilopygus* Latzel in Chalande, Bull. Soc. Hist. Nat., Toulouse, 1886, p. 23.
1888, *Iulus luridus* var. *oedurus* Latzel, in Chalande, Bull. Soc. Hist. Nat., Toulouse, 1888, p. 8. E.

*Cylindroiulus londinensis* var. *teutonicus* (Pocock, 1900).
Syn: 1900, *Iulus teutonicus* Pocock, Ann. & Mag. Nat. Hist. (vii.), **6**, pp. 206-7. E.I.

*Cylindroiulus londinensis* var. *finitimus* Ribaut, 1905, Bull. Soc. d'Hist. Nat. d. Toulouse, p. 3. E.

*Cylindroiulus britannicus* (Verhoeff, 1891).
Syn: 1891, *Iulus britannicus* Verhoeff, Berl. ent. Zeits., **36**, pp. 147-48, pl. viii., figs, 41, 42, 42$\beta$.
1892, *Iulus frisioïdes* Verhoeff, Zool. Anz., **15**, p. 383. E.I.S.

*Cylindroiulus oweni* (Bollman, 1887).
Syn: 1887, *Iulus owenii* Bollman, Entom. Amer., **2**, p. 228.
1891, *Iulus* (*Allaiulus*) *frisius* Verhoeff, Berl. ent. Zeits., **36**, pp. 118 et 133, Taf. vi., figs. 17-21.
1914, *Iulus hesperus* Chamberlin, Canad. Ent., 314. E.I.S.
Chamberlin, 30 June 1921, Proc. Biol. Soc., Washington, **34**, p. 82, says, of this animal: "There seems little doubt that this is the true *luscus* of Meinert; but if *luscus* is held to be indeterminable with certainty, then *owenii* must take precedence over *frisius*. Comparison of American specimens with some from Holland shows complete agreement in the gonopods of the male." The present writer believes that *Iulus luscus* Meinert, 1868 (Naturh. Tidsskr., 3, **5**, p. 9) is not recognizable, at any rate at present, consequently *oweni* is the valid specific name. In some British records of "*Iulus*" *britannicus* (Verhoeff) this millipede is meant.

*Cylindroiulus latistriatus* (Curtis, 1844).
Syn: 1844, *Iulus latistriatus* Curtis, J. Roy. Agri. Soc. Eng., **5**, pt. 1, p. 229. E.

*Cylindroiulus luridus* (C. L. Koch, 1847).
Syn: 1847, *Iulus luridus* C. L. Koch, Syst. d. Myr., p. 111. I.

Sub-Genus LEUCOIULUS Verhoeff, 1895, Verh. Ges., Wien, **44**, p. 152.

*Cylindroiulus* (*Leucoiulus*) *nitidus* (Verhoeff, 1891).
Syn: 1891, *Iulus nitidus* Verhoeff, Berl. ent. Zeits., **36**, pp. 118 et 148, Taf. viii., figs. 43-5. E.

Sub-Class **COLOBOGNATHA** Brandt, 1834, Oken's Isis, p. 704.

Family POLYZONIDAE Gervais, 1844, Ann. d. sci. nat. 3 sér Zool., **2**, p. 70.

POLYZONIUM Brandt, 1834, Oken's Isis, p. 704.

*Polyzonium germanicum* Brandt, 1831. Bull. d. Mém. d. l'Acad. d. St. Pétersb., sér. 6, Math. Phys., **2** (1833), p. xi. E.

## Class **PAUROPODA**

Lubbock, 1866, Trans. Linn. Soc. Lond., **26**, p. 181.

Family PAUROPODIDAE Lubbock, 1866, Trans. Linn. Soc. Lond., **26**, p. 181.
Syn: 1883, *Pauropoda agilia*, Latzel, Verhandl. d. zool.-botan., Gesellschaft, Wien, **33**, p. 127.

STYLOPAUROPUS Cook, 1896, Brandtia, **6**, in pp. 29-32.

*Stylopauropus pedunculatus* (Lubbock, 1866).
Syn: 1866, *Pauropus pedunculatus* Lubbock, Trans. Linn. Soc. Lond., **26**, p. 185. E.

*Stylopauropus pubescens* Hansen, 1901, Vidensk. Medd. f. d. Naturh. Foren., pp. 346-9, pl. 1, figs. 2a-2e. E.

PAUROPUS Lubbock, 1866, Trans. Linn. Soc. Lond., **26**, p. 181, resp. 187.

*Pauropus huxleyi* Lubbock, 1866, Trans. Linn. Soc. Lond., **26**, p. 182. E.

*Pauropus furcifer* Silvestri, 1902, Pauropoda in Berlese, Acari, Myr., etc., p. 65. E.

ALLOPAUROPUS Silvestri, 1902, Pauropoda in Berlese, Acari, Myr., etc., p. 66.

*Allopauropus vulgaris* (Hansen, 1901).
Syn: 1901, *Pauropus vulgaris* Hansen, Vidensk. Medd. f. d. Naturh. Foren., pp. 392-5, pl. v., figs. 2a-2g. E.

*Allopauropus gracilis* (Hansen, 1901).
Syn: 1901, *Pauropus gracilis* Hansen, Vidensk. Medd. f. d. Naturh. Foren., pp. 395-7, pl. v., figs. 3a-3f. E.S.

*Allopauropus danicus* (Hansen, 1901).
Syn: 1901, *Pauropus danicus* Hansen, Vidensk. Medd. f. d. Naturh. Foren., pp. 376-8, pl. iii., figs. 4a-4f. E.

*Allopauropus brevisetis* Silvestri, 1902, Pauropoda in Berlese, Acari, Myr., etc., p. 66. E.

Family EURYPAUROPODIDAE Ryder, 1879, Amer. Naturalist, **13**, p. 611.
Syn: 1883, *Pauropoda tardigrada* Latzel, Verhandl. d. Zool-botan. Gesellschaft, Wien, **33**, p. 127.
1895, *Brachypauropodidae* Kenyon, Tufts Coll. Studies No. **4**, p. 125 (name for family he believed would " eventually prove necessary ").
1896, *Brachypauropodidae* Cook, Brandtia, **6**, p. 29.

BRACHYPAUROPUS Latzel, 1884, Myr. der öst.-ung. Mon., **2**, p. 28.

*Brachypauropus lubbocki* Bagnall, 1911, Trans. Nat. Hist. Soc., Northumberland, Dur. and Newc./Tyne, **4**, p. 60, figs. 1-2. E.

## Class **CHILOPODA**

Latreille, 1817, Le règne animal par Cuvier, **3**, p. 155.

Sub-Class **ANAMORPHA** Haase, 1880, Schlesiens, Chilop. I. Chilop. anamorpha, Breslau.
On genetic grounds Brölemann (1930) does not employ this sub-class in his classification.

Order LITHOBIOMORPHA Pocock, 1895, Myriapoda, in Biologia Centrali-Americana, p. 3.

Family LITHOBIIDAE Newport, 1844, Trans. Linn. Soc. Lond., **19**, p. 275.

LITHOBIUS Leach, 1813, Edinb. Ency., **7**, p. 409.

*Lithobius piceus* L. Koch. 1862, Die Myr.-Gatt. Lithob., p. 49.
The typical form has not been recorded for the British Isles.

*Lithobius piceus britannicus* Bagnall, 1913, V. Derwent Trans. (? p. 118), E.

*Lithobius agilis* C. L. Koch, 1847, Syst. d. Myr., p. 149. I.

*Lithobius lapidicola* Meinert, 1872, Nat. Tidsskr., **8**, p. 328. E.I.?S.

*Lithobius borealis* Meinert, 1868, Nat. Tidsskr., **5**, p. 263. E.?S.

*Lithobius calcaratus* C. L. Koch, 1844, Deutschl. Crust. Myr., etc. Heft **40**, Taf. 23. E.S.

*Lithobius pilicornis* Newport, 1844, Ann. & Mag. Nat. Hist., **13**, p. 96, No. 5 (*char. emend.* Pocock, 1891, Ann. & Mag. Nat. Hist. (vi.), **7**, pp. 372-3).
Syn: 1844, *Lithobius sloanei* Newport, Ann. & Mag. Nat. Hist., **13**, p. 96, No. 6.
1870, *Lithobius longipes* Porath, Oef, Vet. Akad. Förh., **27**, p. 816.
1884-6, *Lithobius galatheae*, Meinert, Vid. Medd. Foren, 1884-6, p. 109. E.

*Lithobius muticus* C. L. Koch, 1847, Syst. d. Myr., 151. E.?

*Lithobius forficatus* (Linné, 1758).
Syn: 1758, *Scolopendra forficata* Linné, Syst. nat. (ed. x.), **1**, p. 638. E.I.S.

*Lithobius variegatus* Leach, 1813, Edinb. Ency., **7**, p. 409.
Non-syn: 1844, *Lithobius variegatus* C. L. Koch, Deutschl. Crust. Myr., etc., Heft **40**, Taf. 21.
Non-syn: 1863, *Lithobius variegatus* C. L. Koch, Die Myr., **2**, p. 21, f. 144.
This species is syn. with *Lithobius mutabilis* L. Koch, 1862 [v. Latz.: d. Myr. d. öst.-ung. M., **1**, pp. 97-101]. E.I.S.

*Lithobius nigrifrons* Latzel et Haase, 1880, Die Myr. der öst-ung. Mon., **1**, (Chilopoden), p. 71. E.

*Lithobius melanops* Newport, 1845, Trans. Linn. Soc. Lond., **19**, p. 371.
Syn: 1847, *Lithobius glabratus* C. L. Koch, Syst. d. Myr., p. 149. E.I.S.
Note: Following Brölemann (1930, 249-50) I am taking the genus *Monotarsobius* Verhoeff, 1905, Zool. Jahrb. Syst. Suppl., **7**, p. 249, into the genus *Lithobius*.

*Lithobius crassipes* L. Koch, 1862, Die Myr.-Gatt. Lithob., p. 71. E.I.S.

*Lithobius duboscqui* Brölemann, 1896.
Syn: 1896, *Lithobius* (*Oligobothrus*) *duboscqui* Brölemann, Feuille des Jeunes Nat., No. **306**, pp. 116-17. E.I.S.
Probably all the records of *Monotarsobius microps* (Meinert, 1868) (Syn: 1868, *Lithobius microps* Meinert, Naturh. Tidsskr. 3, **5**, p. 265) from the British Isles refer to this species.

*Lithobius duboscqui* var. *fosteri* Brade-Birks, 1919, Irish Nat., **28**, p. 4. I.

*Lithobius curtipes* C. L. Koch, 1847, Syst. d. Myr., p. 150. E.
Note: This species has been collected in Cambridgeshire by Dr. E. Barton Worthington, but this is the first published record of the fact; and I am grateful to the collector for allowing this mention to be made.

LAMYCTES Meinert, 1868, Nat. Tidsskr., **5**, p. 266.

*Lamyctes fulvicornis* Meinert, 1868, Nat. Tidsskr., **5**, p. 266. E.I.S.
This is the *Henicops fulvicornis* (Meinert) of some British records.

Order SCUTIGEROMORPHA Pocock, 1895, Myriapoda in Biologia Centrali-Americana, p. 1.

Family SCUTIGERIDAE Gervais, 1837, Ann. d. sci. nat., 2 sér., **7**, p. 48.

SCUTIGERA Lamarck, 1801, Syst. d. anim. s. vert., p. 182.

*Scutigera coleoptrata* (Linné, 1758).
Syn : 1758, *Scolopendra coleoptrata* Linné, Syst. nat. (ed. x.), **1**, p. 637, S.
Perhaps this animal should be included in our fauna on the ground that it is believed to have bred in paper mills in Scotland ; the evidence is cited by Evans, 1907, Proc. Roy. Phy. Soc., Edinb., **16**, p. 410.

Sub-Class **EPIMORPHA** Haase, 1880, SchlesiensChilop. I Chilop. anamorpha, Breslau.
On genetic grounds Brölemann (1930) does not employ this sub-class in his classification.

Order GEOPHILOMORPHA Pocock, 1895, Myriapoda in Biologia Centrali-Americana, p. 35.

Family HIMANTARIIDAE Cook, 1895, Proc. U.S. Nat. Mus., **18**, p. 67.
Syn : 1847, *Notiphilidae* C. L. Koch, Syst. d. Myr., pp. 78 and 83.

HAPLOPHILUS Cook, 1896, Brandtia, **2**, p. 6.
Syn : 1896, *Haplogaster* Verhoeff, Zool. Anz., **19**, pp. 76-7.

*Haplophilus subterraneus* (Shaw, 1789).
Syn : 1789, *Scolopendra subterranea* Shaw, Trans. Linn. Soc. Lond., **2**, p. 7. E.I.S.

STIGMATOGASTER Latzel, 1880, Die Myr. der öst-ung. Mon., **1** (Chilopoden), p. 211.

*Stigmatogaster gracilis* (Meinert, 1870).
Syn : 1870, *Himantarium gracile* Meinert, Naturh. Tidsskr., **7**, p. 32. ?E. I.

Family MECISTOCEPHALIDAE (Verhoeff, 1901).
Syn : 1901, *Mecistocephalinae* Verhoeff, Nova Acta, Acad. Leop. Carol, **77**, No. 5, p. 166.

MECISTOCEPHALUS Newport, 1842, Proc. Zool. Soc., Lond., **119**, p. 178.

*Mecistocephalus carniolensis* (C. L. Koch, 1847).
Syn : 1847, *Clinopodes carniolensis* C. L. Koch, Syst. d. Myr., p. 185. E.S.
Brölemann, 1930, p. 79, indicates that another genus will be required for this animal.

Family SCHENDYLIDAE Cook, 1895, Proc. U.S. Nat. Mus., **18**, p. 70.

HYDROSCHENDYLA Brölemann et Ribaut, 1911, Bull. Soc. Ent. d. France, p. 193.

*Hydroschendyla submarina* (Grube, 1872).
Syn : 1872, *Geophilus* (*Schendyla*) *submarinus* Grube. Mittheilungen über St. Malo und Roscoff und die dortige Meeres- besonders die Annelidenfauna. Abtheilung für Naturwissenschaften und Medecin, 1869-72, Breslau, 1872, pp. 82-3 (mention), 127-9 (description), pl. 1, fig. 5, pl. 2, fig. 1. E.I.

SCHENDYLA Bergsoe et Meinert, 1866, Nat. Tidsskr., **4**, p. 103.

*Schendyla nemorensis* (C. L. Koch, 1837).
Syn : 1837, *Geophilus nemorensis* C. L. Koch, Deutschl. Crust. Myr., etc., Heft **9**, Taf. 4. E.I.S.

Family GEOPHILIDAE (Leach, 1814).
Syn : 1814, *Geophilides* Leach, Trans. Linn. Soc. Lond., **11**, pt. 2, p. 384.

CHAETECHELYNE Meinert, 1870, Nat. Tidsskr., **7**, p. 44, Tab. iii., figs. 20-26.

*Chaetechelyne montana* Meinert, 1870, Nat. Tidsskr. af Sch., **7**, p. 47. E.?

*Chaetechelyne vesuviana* (Newport, 1844).
Syn: 1844, *Geophilus vesuvianus* Newport, Trans. Linn. Soc. Lond., **19**, p. 435. E.

SCOLIOPLANES Bergsoe et Meinert, 1866, Nat. Tidsskr., **4**, p. 98.
Syn: 1814, *Geophilus* (ex p.) Leach et auct. al.
1847, *Stenotaenia* (ex p.) C. L. Koch, Syst. d. Myr., pp. 85 et 187.
1847, *Linotaenia* (ex. p.) C. L. Koch, Syst. d. Myr., pp. 86 et 188.

*Scolioplanes maritimus* (Leach, 1817).
Syn: 1817, *Geophilus maritimus* Leach, Zool. Misc., **3**, p. 44, *t.* 140, figs. 1, 2. E.I.S.

*Scolioplanes acuminatus* (Leach, 1814).
Syn: 1814, *Geophilus acuminatus* Leach, Trans. Linn. Soc. Lond., **11**, p. 386. E.

*Scolioplanes crassipes* (C. L. Koch, 1835).
Syn: 1835, *Geophilus crassipes* C. L. Koch, Deutschl. Crust. Myr., etc., Heft **3**, Taf. 3. E.I.S.

CLINOPODES C. L. Koch, 1847, Syst. d. Myr., p. 184.

*Clinopodes linearis* (C. L. Koch, 1835).
Syn: 1835, *Geophilus linearis* C. L. Koch, Deutschl. Crust. Myr., etc. Heft **3**, Taf. 1.
? Syn: 1835, *Geophilus simplex* Gervais, Mag. Zool. de Guerin, cl. **9**, n. 132, p. 9 (or 37). E.

NECROPHLAEOPHAGUS Newport, 1842, Proc. Zoo. Soc., p. 180.

*Necrophlaeophagus longicornis* (Leach, 1814).
Syn: 1814, *Geophilus longicornis* Leach, Trans. Linn. Soc. Lond., **11**, p. 386.
Syn: (?) 1778, *Scolopendra flava* De Geer, Mem. d. Ins., **7**, p. 561.
Syn: 1842, *Necrophlaeophagus longicornis* (Leach), Newport, Proc. Zool. Soc., p. 180.
1844, *Arthronomalus longicornis* (Leach), Newport, Trans. Linn. Soc. Lond., **19**, p. 430. E.I.S.

GEOPHILUS Leach, 1814, Trans. Linn. Soc. Lond., **11**, p. 384.
Syn: 1866, *Scnipaeus.* Bergsoe et Meinert, Natur. Tidsskr., 3 R., **4**, circa p. 95.

*Geophilus carpophagus* Leach, 1817, Zool. Misc., **3**, p. 43.
Syn: 1844, *Necrophlaeophagus carpophagus* (Leach), Newport, List of (B.M.) Myriapoda, p. 8.
1844, *Arthronomalus carpophagus* (Leach) Newport, Trans. Linn. Soc. Lond., **19**, p. 432.
1866, *Scnipaeus sodalis* Bergsoe et Meinert, Natur. Tidsskr., 3 R., **4**, circa p. 97.
1880, *Geophilus condylogaster* Latzel, Die Myr. d. öst-ung. Mon., **1**, 178. E.I.S.
Note: Whether this is *Arthronomalus crassicornis* Parfitt, 1866, Zoologist, p. 7, is not clear.

*Geophilus insculptus* Attems, 1894, Sitzb. math-nat. Cl. k. Akad. Wiss., Wien, **104** (1895), pp. 163-5, Taf. 1, figs. 9 and 12. E.I.S.
This is undoubtedly the "*G. proximus* C. L. Koch" (1847, Syst. d. Myr., p. 186) of a number of British records. The true *G. proximus* C. L. Koch, is not known to occur in these islands.

*Geophilus electricus* (Linné, 1758).
Syn: 1758, *Scolopendra electrica* Linné, Syst. nat. (ed. x.), **1**, p. 638. E.I.

*Geophilus algarum* Brölemann, 1909, Feuille des Jeunes Nat., sér. 4, **39** ann., No. 466, pp. 208-12. E.

BRACHYGEOPHILUS Brölemann, 1909, Arch. Zool. expér. et gén., **5** sér, **3**, No. 3, p. 338.

*Brachygeophilus truncorum* (Bergsoe et Meinert, 1866).
Syn: 1866, *Geophilus truncorum* Bergsoe et Meinert, Naturh. Tidsskr., 3 R., **4** (p. 14 of reprint), i.e. circa p. 94. E.I.S.

Order SCOLOPENDROMORPHA Pocock, 1895, Myriapoda, in Biologia Centrali-Americana, p. 13.

Family CRYPTOSIDAE Verhoeff, 1907.

CRYPTOPS Leach, 1813, Edinb. Ency., **7**, p. 408.

*Cryptops hortensis* Leach, 1813, Edinb. Ency., **7**, p. 408.
Syn: *Cryptops Savignii* Leach, 1817, Zool. Misc., **3**, p. 42. E.I.S.

*Cryptops anomolans* Newport, 1844, Ann. Mag. Nat. Hist., **13**, p. 100.
Note: Brölemann, 1930, p. 207, treats this species as a synonym of *Cryptops savignyi* Leach, 1817 (see *Cryptops hortensis* Leach). E.

In the foregoing list I have not included a number of the introduced species recorded by R. I. Pocock (1906), in "Antennata" in The Wild Fauna and Flora of the Royal Botanic Gardens, Kew, *Bull. of Misc. Information. Additional Series* **5**. London: H.M. Stationery Office; though I have included some which seem to have wide artificial distribution.

Much might be added regarding sources of information and about publications dealing with the taxonomy of these four interesting classes of Arthropoda, but I shall confine my remarks to brief mention of the work of several investigators. Count von Attems has recently given us a general review of all four classes [1926, in Myriapoda, in Kükenthal's Handbuch der Zoologie, **4**, Berlin-Leipzig: De Gruyter & Co.].

H. W. Brölemann's "Blaniulidae" and "Chilopoda" ["Blaniulidae" in Arch. de Zool. exp. et gén., **61**, pp. 99-453, pls. 1-16, 2 Mai 1923; and "Chilopodes" (Elements d'une Faune des Myriapodes de France), 1930] have been a great help to those who study these animals, and K. W. Verhoeff also has dealt in recent years with the subject of classification (Arthropoda in Bronns Klassen und Ordnungen des Tierreichs, **5**: Leipzig, 1902-33.)

O. Schubart in "Ein Beitrag zur Diplopodenfauna der Niederlande," *Sitz. d. Gesell. nat. Freunde*, 15 Jan. 1929, pp. 106-62, publishes a list of English (British) Diplopoda, pp. 138-41.

# APPLES, THE RELATIVE ORDER OF FLOWERING OF THE DIFFERENT VARIETIES AND ITS BEARING ON CROSS-FERTILIZATION

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THE different varieties of apples, pears, plums and cherries keep to a relative order of blossoming as do snowdrops, crocuses, red dead nettle, primroses, daffodils and other plants; surroundings influence this, but it is possible to say which varieties usually flower early, in mid-season or late.

As many varieties are practically self-unfruitful and all varieties of apple bear fruit more plentifully with pollen of another variety, it is helpful to know something of the order of flowering in order to choose varieties to plant together that are in flower at the same time and avoid planting together a very early flowering variety with one that flowers very late unless there is a mid-season flowering variety which is available to supply pollen to each. Records of the order of flowering have been kept in many parts of the country and they all nearly correspond in order. The longest period-record that I have had the privilege of examining was made by Mr. James Udale at the Worcestershire Experimental Garden at Droitwich, there the time of flowering of different varieties of plums, pears and forty-one kinds of apples was kept for twenty-one years (1900 to 1920); I worked out the average order of flowering of the plums, pears and apples which were mentioned in the Worcestershire papers. In this record the shortest average length of time in flower of the varieties of apple (from commencing to flower till most of the petals had fallen) was nine days in 1908 and 1915 and the longest was thirty-one days in 1906; the average length of time for a variety to be in flower was seventeen days. The earliest blossoming year was 1920 (11 April to 2 May) and the latest 1917 (9 May to 21 May). Another West Country record was made at Hereford in 1894 by Mr. John Watkins; although so long ago, it contains most of the varieties still grown; in that year the average length of time in flower was thirteen days, being in full flower on about the sixth day. The third West Country record is that of the Fruit and Cider Institute at Long Ashton, Gloucestershire; there the dates of flowering were kept for seven years (1908-14); for the different varieties of apples, pears, plums, raspberries, strawberries, black and red and white currants and gooseberries, they record the date of the commencement of blossoming.

Records of the blossoming of apple trees at the Woburn Experimental Fruit Farm (The Duke of Bedford and Spencer U. Pickering) were kept for five years (1905-9), these gave the averages for the commencement to blossom of 117 varieties; the length of time of a variety in flower was fourteen to twenty days, the average being sixteen days.

At Chelmsford, Essex, a record was kept by Mr. W. P. Seabrook in 1920 of the commencement to flower of 101 varieties of apples, the earliest to commence to flower was Irish Peach on 5 April, and the latest Crawley Beauty on 14 May.

At Wisley, Surrey, in the gardens of the Royal Horticultural Society, a record of the average time of full bloom of 168 varieties was kept for four years (1908-11) by

Mr. F. J. Chittenden and was published in the Society's *Journal*, Vol. 37 (1911-12); this is the most complete and accessible list for reference.

Coming to Kent a very careful record of the length of time in flower of different varieties of apple pruned and unpruned and on different kinds of stock was made at the East Malling Fruit Research Station (1919-25); the results appeared in the Annual Report, 1925. At Maidstone, in the Allington Nurseries by the kindness of Mr. E. A. Bunyard in 1928, I kept a record of the time and length of blossoming of 105 varieties.

*Approximate Average Order of Blossoming of the Apples most generally grown for market.*

| | Droitwich, Worcestershire, average of 21 years. | Hereford, 1 year. | Long Ashton, Gloucestershire, average of 7 years. | Woburn, Bedfordshire, average of 5 years. | Chelmsford, Essex, 1 year. | Wisley, Surrey, average of 4 years. | Maidstone, Kent, 1 year. | East Malling, Kent, average of 7 years. | Wye, Kent, average of 4 years. | Average day on which flowering commenced. |
|---|---|---|---|---|---|---|---|---|---|---|
| *EARLY.* | | | | | | | | | | |
| Irish Peach (not recommended, but used as standard of earliness) .. | — | 1 | — | 2·2 | 1 | — | 3 | — | 1·0 | 1·6 |
| Bismarck .. .. .. | 2·2 | 4 | 3·8 | 6·0 | 15 | 11·6 | 15 | 7·1 | 4·5 | 7·7 |
| BEAUTY OF BATH .. | — | 3 | 3·5 | 5·4 | 11 | 12·0 | 11 | 1·0 | 11·0 | 8·2 |
| Warner's King .. .. | 7·0 | 7 | 3·1 | 4·2 | 13 | 10·1 | 13 | — | 9·0 | 8·7 |
| STIRLING CASTLE .. .. | 5·2 | 8 | 4·0 | 6·0 | 18 | 7·5 | 18 | — | 9·0 | 9·0 |
| Lord Grosvenor .. .. | 7·6 | 9 | 8·5 | 7·2 | 16 | 11·7 | 16 | — | — | 10·0 |
| JAMES GRIEVE .. .. | — | — | 6·1 | – | 13 | 13·5 | 13 | 3·7 | 14·0 | 0·7 |
| Gladstone .. .. .. | — | 5 | — | 8·2 | 16 | 16·2 | 16 | 6·2 | 10·0 | 10·9 |
| *MID-SEASON.* | | | | | | | | | | |
| ALLINGTON PIPPIN .. | — | — | 7·0 | 9·4 | 21 | 12·5 | 21 | 4·7 | 12·0 | 12·1 |
| GRENADIER .. .. | — | 12 | — | 10·4 | 21 | 15·2 | 21 | 5·1 | 15·0 | 12·1 |
| COX'S ORANGE PIPPIN .. | 10·4 | 12 | 9·0 | 9·6 | 24 | 11·8 | 24 | 4·7 | 10·5 | 12·2 |
| WORCESTER PEARMAIN .. | 9·2 | 9 | 8·0 | 9·4 | — | 13·0 | 27 | 5·9 | 11·2 | 12·2 |
| Blenheim Orange .. .. | — | 12 | 10·0 | 9·8 | 18 | 14·2 | 18 | ... | 15·2 | 12·5 |
| King of the Pippins .. | 10·1 | 11 | – | 8·8 | — | 13·7 | .. | — | — | 12·5 |
| RIVAL .. .. .. | — | — | 9·1 | — | 22 | 13·5 | 22 | 5·6 | 14·0 | 12·8 |
| BRAMLEY'S SEEDLING .. | 10·5 | 13 | 6·8 | 9·6 | 27 | 15·6 | 27 | · | 9·0 | 13·8 |
| LORD DERBY .. .. | — | 16 | 10·1 | 10·4 | 24 | 13·0 | 24 | 11·5 | 13·5 | 14·1 |
| LANE'S PRINCE ALBERT .. | 10·7 | 20 | 9·5 | 10·0 | 27 | 14·7 | 27 | 12·3 | 13·0 | 14·9 |
| EARLY VICTORIA .. .. | — | — | — | — | 24 | 12·0 | 24 | 6·4 | 15·5 | 15·0 |
| *LATE.* | | | | | | | | | | |
| Lady Sudeley .. .. | — | 18 | 12·0 | 9·2 | 27 | 13·7 | 27 | — | 15·5 | 16·1 |
| NEWTON WONDER .. | — | 16 | 9·8 | 11·4 | 28 | 17·0 | 23 | 11·7 | 14·2 | 16·4 |
| Annie Elizabeth .. .. | — | 17 | 16·4 | 9·6 | 30 | 16·4 | 19 | 11·3 | 15·5 | 16·8 |
| Royal Jubilee .. .. | — | — | 17·3 | 14·4 | — | 20·1 | 23 | — | 23·2 | 19·6 |
| Court Pendu Plât (not recommended, standard of lateness) .. .. | — | 34 | 20·3 | 14.0 | — | 19·5 | 31 | — | 25·0 | 24·0 |
| Crawley Beauty .. | — | — | — | — | 39 | — | — | — | 34·0 | 34·0 |

At Wye in 1908-9 and 1910 I kept a record of the order of flowering and length of time in flower in the College plantation and the Olantigh Fruit garden; this was repeated in 1926 and I give here an average for the four years. The average length of time in flower was seventeen days, full flower on the seventh day. Of varieties that were long in

flower Newton Wonder, Stirling Castle, Lane's Prince Albert and Royal Jubilee were noticed, whilst Blenheim Orange, Lord Derby, Mère de Ménage, Foster's Seedling were the shortest time in flower. At Rolvenden, Kent, an early date for apple blossom was 29 March, in 1920, and a late one 11 May in 1917.

The following may act as a guide as to the varieties that usually flower early, mid-season and late.

*Earliest :*

Cheal's Crimson Crab, Irish Peach (F1), EXQUISITE, MAIDSTONE FAVOURITE, Bismarck (F2), ARTHUR TURNER, Margil (S), Dartmouth Crab (F), Brownlee's Russet (S), LORD LAMBOURNE, Egremont Russet (F3), St. Edmund's Russet (F2), Warner's King (F2), STIRLING CASTLE (F1), RIBSTON PIPPIN (F1), Belle de Boskoop, Cornish Aromatic, Washington (F1), Adam's Pearmain.

*Early :*

BEAUTY OF BATH (S to F3) ; D'Arcy Spice, GRAVENSTEIN, Lord Suffield, Rosemary Russet, Christmas Pearmain (F1), Lord Grosvenor (F1), Baumann's Red Winter Reinette (F1), Norfolk Beauty (F3), Benn's Red (F1), Claygate Pearmain, Miller's Seedling (F1), Sturmer Pippin (F1), Lord Hindlip, Duchess Favourite, Ontario.

*Mid-Season :*

King's Acre Pippin (F3), JAMES GRIEVE (F3), Gladstone (F3), ALLINGTON PIPPIN (F3), GRENADIER (F2), COX'S ORANGE PIPPIN (S), WORCESTER PEARMAIN (F3), CHARLES ROSS (F2) Ex., BLENHEIM ORANGE (F3), Barnack Beauty (F3), King of the Pippins (F3), RIVAL (F3), Duke of Devonshire, PEASGOOD'S NONSUCH (F2) Ex., Pott's Seedling (F1), Ecklinville Seedling (F3), Cutler Grieve, ELLISON'S ORANGE (F3) (this variety is recommended both for quality and for market by the Ministry of Agriculture), WEALTHY Ex., HERRING'S PIPPIN, King of Tompkins County, MONARCH, BRAMLEY'S SEEDLING (F2), LORD DERBY (F2), EMPEROR ALEXANDER Ex., ST. CECILIA, ST. EVERARD (F1), Encore (S), KING GEORGE V, REV. W. WILKS (F1) Ex., Langley Pippin, LAXTON'S SUPERB (F1) (this variety is recommended both for quality and for market by the Ministry of Agriculture).

*Late :*

LANE'S PRINCE ALBERT (S to F3), Early Victoria (F2), Cornish Gilliflower, WELLINGTON (F2), Thomas Rivers, Lady Sudeley (F3), NEWTON WONDER (F3), Annie Elizabeth (F3), GOLDEN NOBLE, Allen's Everlasting, Lord Burghley.

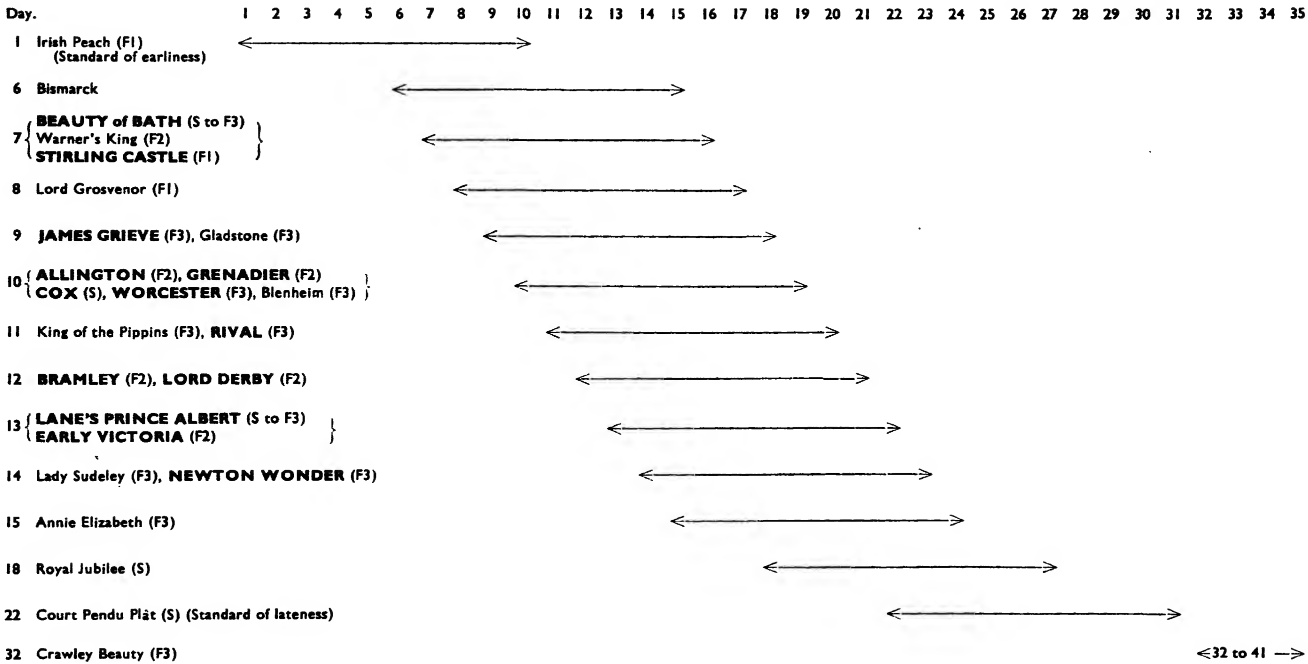
*Latest :*

ORLEANS REINETTE (F3), AMERICAN MOTHER (S), GASCOYNE'S SCARLET (S), Cottenham Seedling, KING EDWARD VII, Coronation (F1), Heusgen's Golden Reinette, Royal Jubilee (S), Court Pendu Plât (S), CRAWLEY BEAUTY ($F_2$).

*Note.*—The varieties printed in CAPITALS are varieties recommended by the Council of the Royal Horticultural Society, either for quality, cropping or for exhibition.

# VARIETIES OF APPLES

## COMMONLY GROWN FOR MARKET, PLACED IN APPROXIMATE RELATIVE ORDER OF FLOWERING.




NOTE 1. Allowing 9 days as the Effective Period for Cross-Pollination (2 days before Full Bloom and 7 days after).

NOTE 2. S=Self-Sterile or practically so ; F3=Occasionally but rarely Self-Fruitful ; F2=Slightly Self-Fruitful ; F1=Considerably Self-Fruitful.

Apple Pollination.

The notes on the degree of self-fruitfulness or of self-sterility given above are based on experiments by M. B. Crane, A. N. Rawes and C. H. Hooper.

All experimenters agree that no apple is sufficiently self-fruitful to plant alone. Bramley's Seedling has been planted alone in block, but it is found to be a mistake; it is better to plant it with another variety every two or three rows, in practice Lord Derby and Lane's Prince Albert are either of them good varieties to plant with it.

One would like to be able to say that any variety will cross pollinate another variety equally well provided it is in flower at the same time, but this is not actually so. Bramley, Newton and Blenheim are not good pollinizers and one would probably not get the best result planting these three together without other kinds. Again one has such facts as that, while Cox's Orange pollinates Bramley perfectly, Bramley is not a good pollinizer for Cox's Orange. Experiment and observation in orchards are both needed. Probably the facts just mentioned are rather unusual, it may however be advantageous to have three varieties rather than two in an orchard. Again it would appear that a self-sterile variety may crop very well provided it is pollinated with a suitable variety. Stirling Castle, a very self-fruitful variety, needs to be thinned or there is too much small fruit and the tree is stunted in growth by over-cropping. In most cases the general rule would seem to be that two varieties will cross pollinate satisfactorily if in flower at the same time, but some cross pollinations may be more successful than others.

Turning to the results of M. B. Crane's excellent work at Merton, one notices that whilst Cox's Orange is a good pollinizer with most varieties it only gave 1 and 2 per cent in the pollination of Ellison's Orange and Laxton's Superb (Cox was a parent to each of these), so that it would be a mistake to plant Cox as a pollinizer for these two varieties. It is of interest to see that Gascoyne's Scarlet which is one of the few absolutely self-sterile varieties matured 18 per cent with Cox's Orange. Worcester Pearmain which matured only 1·3 per cent with its own pollen, matured 8 per cent with Cox's Orange and only 1·3 per cent with Bramley. Royal Jubilee which matured only 0·1 per cent with its own pollen, matured 16 per cent with pollen of Lane's Prince Albert. Bramley appears to be well pollinated by Grenadier; Blenheim Orange by Ellison's Orange; Beauty of Bath matured 1·6 per cent with its own pollen, 12 per cent with Rev. W. Wilks, 11 per cent with Norfolk Beauty, but only 3·5 per cent with Bramley. Lady Sudeley matured 1 per cent with its own pollen and 13·6 per cent with that of Cox's Orange. Newton Wonder matured 1·4 per cent with its own pollen, 8 per cent with Cox's Orange, 6 per cent with Lord Derby, and 5 per cent with Lane's Prince Albert. For Cox's Orange which matures less than 1 per cent with its own pollen, Worcester Pearmain, James Grieve, Beauty of Bath, Stirling Castle, Egremont Russet, give some of the highest yields. It would be helpful to have more information as to the best pollinizers for the well-known market varieties as a guide in planting, taking also into consideration the time of flowering.

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# WEED SURVEY OF THE COLLEGE FARMS, 1933

By R. M. HARRISON, B.Sc., A.R.C.S.

FURTHER progress has been made in 1933 with weed surveys of fields of the College farms. These surveys are of special note because the soils on which they are made have been fully described and classified (Brade-Birks and Furneaux, 1930). The ecological interest is increased because this classification includes the description of the soil series and this description takes into account a number of soil factors which influence the distribution of the flora. The method of carrying out a weed survey, kindly suggested by Dr. Winifred E. Brenchley of the Rothamsted Experimental Station, has already been described by the writer (1931). The following is an outline of the method. The weeds in a field are classified under five headings :

I. DOMINANT, the species which is most abundant. II. SUB-DOMINANT, that second in order. III. DISTRIBUTED, those species which are of general distribution. IV. OCCASIONAL, those of occasional or local distribution. V. SCARCE OR RARE, those species of which only one or two specimens occur.

The classification is supplemented by the following details: (1) LOCALITY. (2) DATE. (3) GEOLOGY. (4) SOIL SERIES. (5) REACTION. (6) MANURING. (7) CROP. (8) PREVIOUS CROP.

The additional detail of POISONOUS SPECIES is given if the survey is carried out on a pasture. Notes are also made of any other points of interest. When a field is on two soil series, a weed survey has been made on each.

The weeds in the classification are listed in the order in which they are placed in Bentham and Hooker's "British Flora".

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(1) LOCALITY, King's Field III. (2) DATE, 11 August 1933. (3) GEOLOGY, Chalky drift. (4) SOIL SERIES, Coldharbour. (5) REACTION, Alkaline. (6) MANURING, 4½ cwt. per acre of artificials, March 1933. (7) CROP, Oats. (8) PREVIOUS CROP, Barley.

WEED CLASSIFICATION :—

I. DOMINANT.

*Polygonum aviculare* L., Knotgrass.

II. SUB-DOMINANT.

*Convolvulus arvensis* L., Field Bindweed.

III. DISTRIBUTED.

*Carduus arvensis* Robs., Creeping Thistle ; *Sonchus arvensis* L., Corn Sowthistle ; *Polygonum Convolvulus* L., Black Bindweed.

IV. OCCASIONAL.

*Æthusa Cynapium* L., Fool's Parsley ; *Linaria spuria* Mill., Male Fluellen ; *Mentha arvensis* L., Field Mint ; *Plantago major* L., Broad-leaved Plantain ; *Euphorbia Peplus* L., Petty Spurge ; *Equisetum arvense* L., Common Horse-tail.

V. Scarce or Rare.

*Papaver Rhœas* L., Field Poppy ; *Brassica Sinapis* Visiani., Charlock ; *Capsella Bursa-pastoris* Medik., Shepherd's-Purse; *Silene Cucubalus* Wibel., Bladder Campion; *Stellaria media* Vill., Chickweed ; *Trifolium pratense* L., Red Clover ; *Tussilago farfara* L., Coltsfoot ; *Senecio vulgaris* L., Groundsel ; *Centaurea nigra* L., Knapweed ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Chenopodium album* L., Fat Hen ; *Rumex* sp., Dock ; *Euphorbia exigua* L., Dwarf Spurge ; *Hordeum sativum* Pers., Barley ; *Agropyrum repens* Beauv., Couch.

Knotgrass was by far the most prevalent of a large number of weed species in this field, but as may be judged from the classification they were present only in small quantities. Coltsfoot was recorded as occurring rarely, an unusual category for this weed ; but this may be explained by the comparative lightness of the soil, a loam with excessive drainage.

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(1) Locality, Walloways, Part I. (2) Date, 17 August, 1933. (3) Geology, Chalky drift. (4) Soil series, Coldharbour. (5) Reaction, Alkaline. (6) Manuring, 5 cwt. per acre of artificials. (7) Crop, Barley. (8) Previous Crop, 1930-1-2, Barley.

WEED CLASSIFICATION :—

I. Dominant.

*Lychnis alba* Mill., White Campion.

II. Sub-dominant.

*Polygonum Convolvulus* L., Black Bindweed.

III. Distributed.

*Stellaria media* Vill., Chickweed ; *Carduus arvensis* Robs., Creeping Thistle ; *Atriplex patula* L., Common Orache.

IV. Occasional.

*Medicago lupulina* L., Black Medick ; *Trifolium dubium* Sibth., Yellow Suckling Clover ; *Linaria spuria* Mill., Male Fluellen ; *Lolium perenne* L., Perennial Rye-grass.

V. Scarce or Rare.

*Brassica Sinapis* Visiani., Charlock ; *Trifolium pratense* L., Red Clover ; *Senecio vulgaris* L., Groundsel ; *Sonchus oleraceus* L., Common Sowthistle ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Solanum tuberosum* L., Potato ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Rumex crispus* L., Curled Dock ; *Polygonum aviculare* L., Knotgrass ; *Avena fatua* L., Wild Oat.

The survey just given applies to about half the field Walloways in which the soil is of the Coldharbour series. The other half is described as Part II, and has soil of the Gore series. The dominant weed, White Campion, is often associated with chalk (Brenchley, 1920) as in this case. Early Potatoes were grown in this field in 1928, and the few specimens observed had survived through four successive Barley crops. The few weeds listed in the "distributed" class indicate a fairly clean crop.

(1) Locality, Walloways, Part II. (2) Date, 17 August 1933. (3) Geology, Chalky drift. (4) Soil series, Gore. (5) Reaction, Alkaline. (6) Manuring, 5 cwt. per acre of artificials. (7) Crop, Barley. (8) Previous Crop, 1930-1-2, Barley.

WEED CLASSIFICATION :—

I. Dominant.

*Polygonum Convolvulus* L., Black Bindweed.

II. Sub-dominant.

*Atriplex patula* L., Common Orache.

III. Distributed.

*Stellaria media* Vill., Chickweed; *Linaria spuria* Mill., Male Fluellen; *Lolium perenne* L., Perennial Rye-grass.

IV. Occasional.

*Brassica Sinapis* Visiani., Charlock; *Medicago lupulina* L., Black Medick; *Carduus arvensis* Robs., Creeping Thistle; *Sonchus arvensis* L., Corn Sowthistle.

V. Scarce or Rare.

*Ranunculus repens* L., Creeping Buttercup; *Lychnis alba* Mill., White Campion; *Trifolium pratense* L., Red Clover; *Trifolium dubium* Sibth., Yellow Suckling Clover; *Potentilla reptans* L., Cinquefoil; *Senecio vulgaris* L., Groundsel; *Veronica persica* Poir., Buxbaum's Speedwell; *Euphorbia Helioscopia* L., Sun Spurge.

The flora in this half of the field was somewhat similar to that in Part I, an exception being White Campion, of which only one or two specimens were found. It is difficult to see any striking differences in the two soils which would account for this distribution. The Coldharbour soil is one in which plants would root more easily, the chalk occurring in it in the form of small lumps, whereas the Gore soil has the chalk more intimately mixed in the loam and is more highly calcareous.

Although the difference in soil series most probably accounts for the variations there is another factor which must be considered. Forty years ago a fence divided the field almost along the junction of the two soils. This second part belonged to a different owner, and would therefore have received different management. It might be expected however that forty years of similar treatment would have removed any previous differences in the weed flora.

(1) Locality, The Park Field, Part I. (2) Date, 17 August 1933. (3) Geology, Valley Brick-earth over chalk. (4) Soil series, Wye. (5) Reaction, Alkaline. (6) Manuring, 3½ cwt. per acre of artificials, November 1932, ½ cwt. per acre Sulphate of Ammonia, March 1933. (7) Crop, Wheat. (8) Previous Crop, Wheat, Oats at one end.

WEED CLASSIFICATION :—

I. Dominant.

*Mentha arvensis* L., Field Mint.

II. Sub-dominant.

*Carduus arvensis* Robs., Creeping Thistle.

III. Distributed.

*Plantago major* L., Broad-leaved Plantain ; *Polygonum aviculare* L., Knotgrass ; *Polygonum Convolvulus* L., Black Bindweed.

IV. Occasional.

*Ranunculus repens* L., Creeping Buttercup ; *Capsella Bursa-pastoris* Medik., Shepherd's Purse ; *Stellaria media* Vill., Chickweed ; *Sonchus arvensis* L., Corn Sowthistle ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Rumex obtusifolius* L., Broad Dock ; *Agrostis alba* L., var. *stolonifera*, Fiorin.

V. Scarce or Rare.

*Lychnis alba* Mill., White Campion ; *Trifolium pratense* L., Red Clover ; *Cratægus Oxyacantha* L., Hawthorn ; *Æthusa Cynapium* L., Fool's Parsley ; *Senecio vulgaris* L., Groundsel ; *Solanum tuberosum* L., Potato ; *Linaria spuria* Mill., Male Fluellen ; *Atriplex patula* L., Common Orache ; *Polygonum Persicaria* L., Persicaria ; *Agropyrum repens* Beauv., Couch ; *Dactylis glomerata* L., Cock's-foot.

This was a fairly clean field. The dominant weed, the aromatic Field Mint, spreads both by rhizomes and seeds. It has been described by Long (1929) as a very troublesome weed of arable land in some districts.

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(1) Locality, The Park Field, Part II. (2) Date, 17 August 1933. (3) Geology, Chalky drift. (4) Soil series, Coldharbour. (5) Reaction, Alkaline. (6) Manuring, 3½ cwt. per acre of artificials, November 1932, ½ cwt. per acre of Sulphate of Ammonia, March 1933. (7) Crop, Wheat. (8) Previous Crop, Wheat, Oats at one end.

WEED CLASSIFICATION :—

I. Dominant.

*Mentha arvensis* L., Field Mint.

II. Sub-dominant.

*Carduus arvensis* Robs., Creeping Thistle.

III. Distributed.

*Ranunculus repens* L., Creeping Buttercup; *Polygonum Convolvulus* L., Black Bindweed.

IV. Occasional.

*Stellaria media* Vill., Chickweed ; *Sonchus arvensis* L., Corn Sowthistle ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Linaria spuria* Mill., Male Fluellen ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Rumex obtusifolius* L., Broad Dock ; *Polygonum aviculare* L., Knotgrass.

V. Scarce or Rare.

*Capsella Bursa-pastoris* Medik., Shepherd's Purse ; *Lychnis alba* Mill., White Campion ; *Trifolium pratense* L., Red Clover ; *Senecio vulgaris* L., Groundsel ; *Taraxacum officinale* Weber, Dandelion ; *Rumex crispus* L., Curled Dock ; *Agrostis alba* L., var.

*stolonifera*, Fiorin ; *Agropyrum repens* Beauv., Couch ; *Lolium perenne* L., Perennial Rye-grass.

The Park Field has soils of two series, Part I, Wye, and Part II, Coldharbour. In both cases the weed flora was similar, the " dominant " and " sub-dominant " weeds being the same. Broad-leaved Plantain, distributed throughout Part I and absent in Part II, was their most striking difference.

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(1) LOCALITY, Field A, Part I. (2) DATE, 16 August 1933. (3) GEOLOGY, Valley Brick-earth over Chalk. (4) SOIL SERIES, Wye. (5) REACTION, Alkaline. (6) MANURING, 1 cwt. per acre of Sulphate of Ammonia, March. (7) CROP, Wheat. (8) PREVIOUS CROP, " Seeds " : Wild White Clover, Red Clover and Perennial Rye-grass. A strip of Potatoes at one side.

WEED CLASSIFICATION :—

I. DOMINANT.

*Polygonum aviculare* L., Knotgrass.

II. SUB-DOMINANT.

*Convolvulus arvensis* L., Field Bindweed.

III. DISTRIBUTED.

*Stellaria media* Vill., Chickweed ; *Plantago major* L., Broad-leaved Plantain ; *Poa annua* L., Annual Meadow-grass.

IV. OCCASIONAL.

*Ranunculus repens* L., Creeping Buttercup ; *Carduus arvensis* Robs., Creeping Thistle ; *Sonchus arvensis* L., Corn Sowthistle ; *Solanum tuberosum* L., Potato ; *Linaria spuria* Mill., Male Fluellen ; *Polygonum Convolvulus* L., Black Bindweed.

V. SCARCE OR RARE.

*Trifolium pratense* L., Red Clover ; *Æthusa Cynapium* L., Fool's Parsley ; *Sonchus oleraceus* L., Common Sowthistle ; *Taraxacum officinale* Weber, Dandelion ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Veronica agrestis* L., Procumbent Speedwell ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Mentha arvensis* L., Field Mint ; *Chenopodium album* L., Fat Hen ; *Rumex obtusifolius* L., Broad Dock ; *Euphorbia Peplus* L., Petty Spurge ; *Agrostis alba* L., var. *stolonifera*, Fiorin ; *Lolium perenne* L., Perennial Rye-grass ; *Lolium italicum* Braun., Italian Rye-grass ; *Agropyrum repens* Beauv., Couch.

This was a fairly clean field but Knotgrass was widespread despite the reduction of this weed by a " seeds " crop in 1932.

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(1) LOCALITY, Field A, Part II. (2) DATE, 16 August 1933. (3) GEOLOGY, Chalky drift. (4) SOIL SERIES, Coldharbour. (5) REACTION, Alkaline. (6) MANURING, 1 cwt. per acre of Sulphate of Ammonia, March. (7) CROP, Wheat. (8) PREVIOUS CROP, " seeds " : Wild White Clover, Red Clover and Perennial Rye-grass.

WEED CLASSIFICATION :—

I. DOMINANT.

*Polygonum aviculare* L., Knotgrass.

II. Sub-dominant.

*Ranunculus repens* L., Creeping Buttercup.

III. Distributed.

*Convolvulus arvensis* L., Field Bindweed ; *Linaria spuria* Mill., Male Fluellen ; *Plantago major* L., Broad-leaved Plantain ; *Polygonum Convolvulus* L., Black Bindweed.

IV. Occasional.

*Brassica Sinapis* Visiani., Charlock ; *Stellaria media* Vill., Chickweed ; *Carduus arvensis* Robs., Creeping Thistle ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Atriplex angustifolia* Sm., Spreading Orache ; *Poa annua* L., Annual Meadow-grass.

V. Scarce or Rare.

*Papaver Rhœas* L., Field Poppy; *Trifolium pratense* L., Red Clover; *Senecio vulgaris* L., Groundsel ; *Sonchus arvensis* L., Corn Sowthistle ; *Sonchus oleraceus* L., Common Sowthistle ; *Veronica agrestis* L., Procumbent Speedwell ; *Rumex obtusifolius* L., Broad Dock ; *Euphorbia exigua* L., Dwarf Spurge ; *Mercurialis annua* L., Annual Mercury.

One half of Field A, Part I, is on soil of the Wye series, and the other half, Part II, is on soil of the Coldharbour series. Knotgrass was not quite so abundant in Part II, although clearly " dominant ". Creeping Buttercup was more widespread and Field Bindweed less so. In this part of the field there was a strip on which the Wheat had been broadcast instead of being drilled and it had not taken well. Weeds similar to those of the rest of Part II were present but in very much greater numbers, the ground being densely covered with them. The only variation in the classification was that Charlock was in the " distributed " class instead of being " scarce or rare ".

(1) Locality, Field D, Part I. (2) Date, 21 August 1933. (3) Geology, Valley Brick-earth over Chalk. (4) Soil series, Wye. (5) Reaction, Alkaline. (6) Manuring, 3½ cwt. per acre of artificials. (7) Crop, Wheat, undersown with Wild White Clover, 4 lb., Perennial Rye-grass, 12 lb. and Broad Red Clover, 10 lb. per acre. (8) Previous Crop, Barley.

WEED CLASSIFICATION : –

I. Dominant.

*Mentha arvensis* L., Field Mint.

II. Sub-dominant.

*Carduus arvensis* Robs., Creeping Thistle.

III. Distributed.

*Stellaria media* Vill., Chickweed ; *Medicago lupulina* L., Black Medick ; *Convolvulus arvensis* L., Field Bindweed ; *Polygonum aviculare* L., Knotgrass ; *Polygonum Convolvulus* L., Black Bindweed.

IV. Occasional.

*Sonchus arvensis* L., Corn Sowthistle ; *Plantago major* L., Broad-leaved Plantain ; *Rumex* sp., Dock.

V. SCARCE OR RARE.

*Ranunculus repens* L., Creeping Buttercup; *Papaver Rhœas* L., Field Poppy; *Senecio vulgaris* L., Groundsel; *Anagallis arvensis* L., Scarlet Pimpernel; *Linaria spuria* Mill., Male Fluellen; *Euphorbia exigua* L., Dwarf Spurge.

Part I of this field on the Wye soil series had a very similar flora to that on The Park Field, Part I, which was on the same soil. Field D was a fairly clean field with a small number of weed species. Among this number, however, were several notoriously bad weeds which would soon cause extensive damage if the field were ever poorly managed.

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(1) LOCALITY, Little Crabbs. (2) DATE, 15 August 1933. (3) GEOLOGY, Chalky drift. (4) SOIL SERIES, Sparks. (5) REACTION, Alkaline. (6) MANURING, 4¼ cwt. per acre of artificials, March 1933. (7) CROP, Wheat, re-sown Oats. (8) PREVIOUS CROP, Oats.

WEED CLASSIFICATION :—

I. DOMINANT.

*Convolvulus arvensis* L., Field Bindweed.

II. SUB-DOMINANT.

*Medicago lupulina* L., Black Medick.

III. DISTRIBUTED.

———

IV. OCCASIONAL.

*Veronica persica* Poir., Buxbaum's Speedwell; *Chenopodium album* L., Fat Hen; *Hordeum sativum* Pers., Barley.

V. SCARCE OR RARE.

*Rosa* sp., Wild Rose; *Senecio vulgaris* L., Groundsel; *Carduus arvensis* Robs., Creeping Thistle; *Sonchus oleraceus* L., Common Sowthistle; *Anagallis arvensis* L., Scarlet Pimpernel; *Convolvulus sepium* L., Great Bindweed; *Linaria spuria* Mill., Male Fluellen; *Atriplex angustifolia* Sm., Spreading Orache; *Rumex* sp., Dock; *Polygonum aviculare* L., Knotgrass; *Polygonum Convolvulus* L., Black Bindweed; *Euphorbia Peplus* L., Petty Spurge; *Lolium perenne* L., Perennial Rye-grass.

This was a very clean field with few weeds, Field Bindweed being "dominant". This very common weed has been described by Percival as "one of the worst pests of agriculture".

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(1) LOCALITY, Sharbrooks. (2) DATE, 15 August 1933. (3) GEOLOGY, Alluvial drift, mainly of Gault origin. (4) SOIL SERIES, Sharbrooks. (5) REACTION, Alkaline. (6) MANURING, per acre: 12 tons farmyard manure, 3 cwt. Superphosphate, 2 cwt. Muriate of Potash, 1 cwt. Sulphate of Ammonia, ¾ cwt. Steamed Bone-flour, in April when crop was sown; 1 cwt. per acre Nitrate of Soda on 1 June when crop was singled. (7) CROP, Mangels. (8) PREVIOUS CROP, Spring Wheat.

WEED CLASSIFICATION :—

I. DOMINANT.

*Carduus arvensis* Robs., Creeping Thistle.

II. SUB-DOMINANT.

*Galium Aparine* L., Cleavers.

III. DISTRIBUTED.

*Mentha arvensis* L., Field Mint ; *Plantago major* L., Broad-leaved Plantain.

IV. OCCASIONAL.

*Trifolium pratense* L., Red Clover ; *Convolvulus arvensis* L., Field Bindweed ; *Myosotis arvensis* Hoffm., Field Forget-me-not ; *Linaria spuria* Mill., Male Fluellen ; *Polygonum aviculare* L., Knotgrass ; *Polygonum Convolvulus* L., Black Bindweed ; *Equisetum arvense* L., Common Horse-tail.

V. SCARCE OR RARE.

*Ranunculus repens* L., Creeping Buttercup ; *Brassica oleracea* L. var., Marrow-stem Kale ; *Capsella Bursa-pastoris* Medik., Shepherd's Purse ; *Stellaria media* Vill., Chickweed ; *Geranium molle* L., Dove's-foot Crane's-bill ; *Trifolium repens* L., Wild White Clover ; *Sonchus oleraceus* L., Common Sowthistle ; *Anagallis arvensis* L., Scarlet Pimpernel ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Chenopodium album* L., Fat Hen ; *Atriplex patula* L., Common Orache ; *Rumex* sp., Dock ; *Urtica urens* L., Annual Nettle ; *Agropyrum repens* Beauv., Couch ; *Lolium perenne* L., Perennial Rye-grass ; *Dactylis glomerata* L., Cock's-foot ; *Poa annua* L., Annual Meadow-grass ; *Poa trivialis* L., Rough-stalked Meadow-grass.

This field has soils of heavier textures than those previously described, the surface soil being silty loam to silt loam, and the sub-soil is a heavier yellowish-brown drift. The drainage is poor. The " dominant " weed, Creeping Thistle, widespread over the entire field, is found on many kinds of soil, but several other species present such as Cleavers, Field Mint and Common Horse-tail are often associated with heavy land ; the last-named weed was seen only at the lower end of the field and it is often an indicator of poor drainage. As may be judged by the presence of only two species in the " distributed " class, this was a very clean crop.

(1) LOCALITY, Bushy Field. (2) DATE, 15 August 1933. (3) GEOLOGY, Alluvial drift, mainly of Gault origin. (4) SOIL SERIES, Sharbrooks. (5) REACTION, Alkaline. (6) MANURING, 1 cwt. per acre of Sulphate of Ammonia, January 1933. (7) CROP, Temporary ley : Wild White Clover, 2 lb. ; Broad Red Clover, 10 lb. and Perennial Rye-grass, 12 lb. per acre. Sown 1932. (8) PREVIOUS CROP, 1930-1-2, Wheat, 1926 a " tumbledown " pasture.

WEED CLASSIFICATION :—

I. DOMINANT.

*Ranunculus repens* L., Creeping Buttercup.

II. Sub-dominant.

*Plantago major* L., Broad-leaved Plantain.

III. Distributed.

*Mentha arvensis* L., Field Mint ; *Rumex* sp., Dock ; *Agrostis alba* L., var. *stolonifera*, Fiorin.

IV. Occasional.

*Brassica Sinapis* Visiani., Charlock ; *Geranium dissectum* L., Cut-leaved Crane's-bill ; *Carduus arvensis* Robs., Creeping Thistle ; *Sonchus arvensis* L., Corn Sowthistle ; *Myosotis arvensis* Hoffm., Field Forget-me-not ; *Plantago lanceolata* L., Ribwort Plantain; *Lolium italicum* Braun., Italian Rye-grass ; *Bromus sterilis* L., Sterile Brome-grass.

V. Scarce or Rare.

*Brassica oleracea* L., Cabbage ; *Geranium molle* L., Dove's-foot Crane's-bill ; *Potentilla anserina* L., Silverweed ; *Silaus pratensis* Bess., Pepper Saxifrage ; *Carduus lanceolatus* L., Spear-thistle ; *Lapsana communis* L., Nipplewort ; *Convolvulus arvensis* L., Field Bindweed ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Prunella vulgaris* L., Self-heal ; *Chenopodium album* L., Fat Hen ; *Holcus lanatus* L., Yorkshire Fog ; *Dactylis glomerata* L., Cock's-foot.

Creeping Buttercup and Broad-leaved Plantain were widespread throughout this fairly weedy field which had a flora very like that of the Sharbrooks Field on the same soil series. Several species, such as Charlock, Cut-leaved Crane's-bill, Corn Sowthistle, Field Mint and Broad-leaved Plantain, are characteristic of heavy land. This field was a " tumbledown " pasture in 1926, and a large proportion of the weeds indicate this former grassland condition.

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(1) Locality, Westons, Part I. (2) Date, 15 August 1933. (3) Geology, Alluvial drift, highly calcareous. (4) Soil series, Brook. (5) Reaction, Alkaline. (6) Manuring, 10 cwt. per acre, Basic Slag, December 1932 ; 1 cwt. per acre Sulphate of Ammonia, January 1933. (7) Crop, Temporary ley ; Wild White Clover, 2 lb., Broad Red Clover, 10 lb. and Perennial Rye-grass, 12 lb. per acre. (8) Previous Crop, Barley.

WEED CLASSIFICATION :—

I. Dominant.

*Tussilago Farfara* L., Coltsfoot.

II. Sub-dominant.

*Plantago major* L., Broad-leaved Plantain.

III. Distributed.

*Ranunculus repens* L., Creeping Buttercup ; *Geranium dissectum* L., Cut-leaved Crane's-bill ; *Medicago lupulina* L., Black Medick ; *Rumex* sp., Dock ; *Agrostis alba* L., var. *stolonifera*, Fiorin.

IV. Occasional.

*Carduus arvensis* Robs., Creeping Thistle ; *Sonchus arvensis* L., Corn Sowthistle ; *Convolvulus arvensis* L., Field Bindweed ; *Plantago lanceolata* L., Ribwort Plantain.

V. Scarce or Rare.

*Papaver Rhœas* L., Field Poppy ; *Cerastium vulgatum* L., Mouse-ear Chickweed ; *Æthusa Cynapium* L., Fool's Parsley ; *Heracleum Sphondylium* L., Hog-weed ; *Sherardia arvensis* L., Field Madder ; *Lapsana communis* L., Nipplewort ; *Veronica persica* Poir., Buxbaum's Speedwell ; *Mentha arvensis* L., Field Mint ; *Equisetum arvense* L., Common Horse-tail.

The soil in this half of the field is a chalky silt loam with a heavier sub-soil, poorly drained. The flora consisted mainly of species characteristic of heavy land, with Coltsfoot widespread throughout this half.

(1) Locality, Westons, Part II. (2) Date, 15 August 1933. (3) Geology, Alluvial drift, mainly of Gault origin. (4) Soil series, Sharbrooks. (5) Reaction, Alkaline. (6) Manuring, 10 cwt. per acre Basic Slag, December 1932 ; 1 cwt. per acre Sulphate of Ammonia, January 1933. (7) Crop, Temporary ley ; Wild White Clover, 2 lb., Broad Red Clover, 10 lb. and Perennial Rye-grass, 12 lb. per acre. (8) Previous Crop, Barley.

WEED CLASSIFICATION :—

I. Dominant.

*Agrostis alba* L., var. *stolonifera*, Fiorin.

II. Sub-dominant.

*Plantago major* L., Broad-leaved Plantain.

III. Distributed.

*Tussilago Farfara* L., Coltsfoot ; *Convolvulus arvensis* L., Field Bindweed.

IV. Occasional.

*Geranium dissectum* L., Cut-leaved Crane's-bill ; *Medicago lupulina* L., Black Medick ; *Carduus arvensis* Robs., Creeping Thistle ; *Plantago lanceolata* L., Ribwort Plantain ; *Rumex* sp., Dock.

V. Scarce or Rare.

*Ranunculus repens* L., Creeping Buttercup ; *Cerastium vulgatum* L., Mouse-ear Chickweed ; *Matricaria inodora* L., Scentless Mayweed ; *Senecio vulgaris* L., Groundsel ; *Sonchus arvensis* L., Corn Sowthistle ; *Lapsana communis* L., Nipplewort ; *Veronica persica* Poir., Buxbaum's Speedwell.

The soil in this half of the field was not so calcareous as that of Part I, but it was similarly heavy and had poor drainage. Fiorin was more abundant, with Coltsfoot and Black Medick less so. The same species typical of heavy land occurred in this half. The field was fairly clean in spite of the presence of several potentially rampant weeds.

The weeds surveys described above indicate a close association between the soil and the flora. This is particularly emphasized in those cases where one field contains soils belonging to two series, as management and crop differences are absent.

The writer wishes to express his appreciation of Mr. B. S. Furneaux's kind assistance with regard to the soil descriptions.

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# A METHOD OF ESTIMATING THE STARCH EQUIVALENT OF MEADOW HAYS

By M. A. Knox, *Department of Economics*, and I. B. Prowse, *Department of Chemistry*.

The careful feeding of milking cows upon scientifically balanced rations has for many years been the practice of an increasing number of farmers. In compiling these rations consideration is first given to a basal ration which shall supply the animals with sufficient food to maintain their metabolism at a normal level. Hay commonly forms the bulk of this basal ration and accordingly the feeding value of the hay becomes a matter of some importance. Hay is extraordinarily variable as to its feeding value ; its quality being affected by such factors as the nature of the herbage, the fertility of the soil, the climate of the district, the time of cutting, the weather conditions during making and the method of making. Figures are available for the composition of meadow hays of different qualities and it has been usual to assign a sample of meadow hay, upon inspection, to one or other of the specified qualities such as " very good ", " good " or " poor ". *It has become increasingly apparent that this assignation of samples of hay to arbitrary standards, having only one analytical interpretation, is not entirely satisfactory.* A brief example will illustrate the way in which an error in the feeding of milking cows may arise from this source.

Assuming a case of a 10 cwt. cow giving three gallons of milk daily, the accepted food requirements are :

| | | |
|---|---|---|
| (a) For maintenance | .. | 6·5 lb. starch equivalent including 0·7 lb. digestible protein. |
| (b) For 3 gallons of Milk | .. | 7·5 lb. starch equivalent including 1·8 lb. digestible protein. |
| Total | .. | 14·0 lb. starch equivalent including 2·5 lb. digestible protein. |

Now the figures given in the Ministry of Agriculture's publication *Rations for Livestock* (Bulletin No. 48, 1933) are :

| | *Starch Equivalent (S.E.).* |
|---|---|
| Poor meadow hay .. .. .. | 22 |
| Good meadow hay .. .. .. | 37 |
| Very good meadow hay .. .. | 48 |

If a farmer rates his hay as " good " and accordingly calculates to obtain 7·4 lb. of starch equivalent from a ration of 20 lb. of hay he arranges for the supplementary

ration to supply the remaining 6·6 lb. of starch equivalent. It is clear that if the hay is not, in reality, up to this standard but, being only moderate in quality, has a starch equivalent of 30, then the 20 lb. basal ration will supply only 6 lb. of starch equivalent. The total ration for the cow will thus be deficient in starch equivalent by 1·4 lb. ***which is*** 10 ***per cent*** of the total quantity. If the yield of milk is less than three gallons the percentage error will be greater ; thus, for a two gallon yield, the deficiency would be 12·2 per cent of the required ration. It may be argued that farmers are quite able to judge the quality of their meadow hay with sufficient accuracy for all practical purposes. We would suggest, in reply to this, that the limited reference provided by only three specified qualities of hay allows of too wide a margin of error. In addition, it is our experience in Kent and Surrey that, not only do some farmers admit the difficulty of assessing the quality of their hay, but that a number of them are liable to rate it too highly. Further, it appears probable that, in spite of the wide variations which may be found in the quality of hay from any one field or locality, there is a limit to the excellence of the hay which can be grown at a reasonable cost in any one locality and that this may be either greater or less than the limiting quality of hay grown in another locality. Thus, what may be classed as " good " hay in one district may be termed no more than " moderate " by farmers in another district. In this way the figures given for the composition of different arbitrary qualities of hay may come to be applied, in some districts, to hays of a quality to which they do not properly refer.

Granted then that there is a need for the more accurate estimation of the feeding value of hay there arises the difficulty of arriving at this estimation. The figures published for the three qualities of hay already quoted are based on a series of elaborate digestibility experiments which cannot be applied wholesale to a large number of hay samples. An attempt has been made therefore to estimate the starch equivalent of hay by carrying out an ordinary laboratory analysis.

The following points therefore became the main objective of the work to which this paper refers :

1. To suggest a method of arriving at an approximate starch equivalent value for hay by calculation from a laboratory analysis.

2. To supply information enabling farmers to have a more accurate idea of the feeding value of a foodstuff upon which they rely so much.

3. To ascertain if farmers in Kent and Surrey were justified in classifying their better samples of hay as " good " and accordingly basing their rationing upon the starch equivalent value given for hays of that designation in official publications.

4. To observe, if possible, whether the results justified the adoption of the necessary empiricism for which the calculation calls.

From the published figures of hay analyses it can be observed that the difference between good and bad hay is largely a matter of the protein and fibre contents. The better the hay the higher the protein content and the lower the fibre. The other constituents do not show a sufficient variation to be significant. In the method adopted the only determinations made upon each sample of hay were the total protein and fibre contents since it was necessary to suggest a method suitable for use in advisory service where a fairly large number of samples may be presented and where, consequently, quick and simple procedure is desired.

Bulk samples were obtained, with as much care as was practicable to ensure their being representative, from stacks which had been standing for some months. From these samples smaller ones were withdrawn in the laboratory, ground to pass a 1 mm. sieve and the protein and fibre determined. Two starch equivalent values were calculated for each sample; the one based on the protein content alone and the other based on the fibre content alone. Two graphs were prepared, one showing the protein content of the three qualities of meadow hay given in *Rations for Livestock* and their respective starch equivalents, the other showing the fibre contents and their respective starch equivalents. The protein and fibre contents found for each hay sample were separately plotted on the appropriate graphs and the two distinct starch equivalent values read off.

It was not to be expected, of course, that the two figures so obtained would always show close agreement. The protein content, however, must be considered to be the more important factor influencing the quality of the hay both on account of the more accurate method of its determination and its more direct significance as food. The final single figure—which we have termed the "presumptive starch equivalent" was obtained by taking twice the figure obtained from the protein content plus that from the fibre content, and dividing by three. Thus, if the starch equivalent estimated from the protein content is 30 while that estimated from the fibre content is 36, the presumptive starch equivalent is $\frac{(30\times 2)+36}{3}=32$. It should be noted that the starch equivalents separately calculated from fibre and protein were in such close agreement in the case of "good" hays that the above calculation gives the same presumptive starch equivalent as would have been shown by taking a simple average of the two readings. The decision to adopt the method of calculation described, however, was prompted by the observation that for nearly all the hays of poor or moderate quality the starch equivalent estimated from the protein was lower than that estimated from the fibre content. A bias in favour of the lower figure was considered justifiable, particularly as this meant "weighting" the final figure in favour of the protein—the more valuable and more accurately determined constituent.

In the accompanying table the protein and fibre contents of thirty-one samples of meadow hay are given together with the starch equivalent values. Examination of the figures shows that of the thirty-one samples, fifteen had an estimated starch equivalent based on protein alone of twenty-five or less and might be termed poor. It is noticeable that in all but two of these poorer samples the starch equivalent calculated from the protein was markedly lower than that calculated from the fibre content. In eleven of these cases the difference between the two estimated starch equivalents was more than nine units. Thus in all these samples the presumptive starch equivalent is somewhat higher than that calculated from protein alone. The figures would also appear to suggest that the fibre content of poor quality hays is not necessarily high in proportion and that in these samples it is not normally as high as that given in *Rations for Livestock* for "poor" hay.

There are only seven cases in which the starch equivalent calculated from protein exceeds the starch equivalent calculated from the fibre and all of these are in samples which may be termed moderate to good. It appears from these results that the fibre content of the better samples of hay may not be as low as would be inferred from previously published figures and that a moderately high fibre content is not necessarily an index of poor quality hay.

*Table of Analyses of Meadow Hays and their Calculated Starch Equivalents.*

| Sample No. | Protein % | Fibre % | S.E. estimated from Protein. | S.E. estimated from Fibre. | Difference. | "Presumptive" S.E. adopted. |
|---|---|---|---|---|---|---|
| | | GOOD :— S.E. 37 OR OVER. | | | | |
| 29 | 10·76 | 25·65 | 40 | 38 | + 2·0 | 39 |
| 23 | 9·97 | 24.05 | 38 | 40·5 | − 2·5 | 39 |
| 13 | 9·80 | 26.75 | 37·5 | 36 | + 1·5 | 37 |
| | | MODERATE TO GOOD :—S.E. 30–36. | | | | |
| 1 | 9·71 | 28·10 | 37 | 33 | + 4·0 | 35 |
| 3 | 9·58 | 28·85 | 36·5 | 31·5 | + 5·0 | 35 |
| 2 | 9·19 | 27·85 | 33·5 | 34 | − 0·5 | 34 |
| 11 | 8·92 | 26·75 | 31·5 | 36 | − 4·5 | 33 |
| 25 | 8·62 | 25·20 | 29·5 | 39 | − 9·5 | 33 |
| 20 | 9·10 | 29·65 | 33 | 30 | + 3·0 | 32 |
| 30 | 8.53 | 26·10 | 29 | 37·5 | − 8·5 | 32 |
| 9 | 8·40 | 25·65 | 28 | 38 | − 10·0 | 31 |
| 18 | 8·44 | 27·65 | 28·5 | 34 | − 5·5 | 30 |
| 4 | 8·31 | 27·35 | 27·5 | 35 | − 7·5 | 30 |
| | | POOR TO MODERATE :—S.E. 22–29. | | | | |
| 19 | 8·88 | 31·95 | 31·5 | 25 | + 6·5 | 29 |
| 21 | 8·66 | 30·95 | 30 | 27·5 | + 2·5 | 29 |
| 24 | 8·45 | 29·20 | 28·5 | 31 | − 2·5 | 29 |
| 15 | 7·96 | 26·65 | 25 | 36·5 | − 11·5 | 29 |
| 27 | 7·[illegible] | 25·10 | 24 | 39 | − 15·0 | 29 |
| 26 | 7·57 | 25·55 | 22·5 | 38 | − 15·5 | 28 |
| 28 | 8·00 | 29·30 | 25 | 31 | − 6·0 | 27 |
| 16 | 7·74 | 31·25 | 24 | 26·5 | − 2·5 | 25 |
| 14 | 7·42 | 28·35 | 21·5 | 32·5 | − 11·0 | 25 |
| 22 | 7·83 | 32·20 | 24 | 25 | − 1·0 | 24 |
| 10 | 7·44 | 30·60 | 22 | 28 | − 6·0 | 24 |
| 8 | 7·35 | 29·25 | 21 | 31 | − 10·0 | 24 |
| 7 | 7·11 | 28·50 | 19 | 32·5 | − 13·5 | 24 |
| 12 | 7·09 | 27·30 | 18·5 | 35·5 | − 16·5 | 24 |
| | | POOR :—S.E. BELOW 22. | | | | |
| 31 | 6·63 | 29·45 | 16 | 30 | − 14·0 | 21 |
| 6 | 6·69 | 29·70 | 16·5 | 30 | − 13·5 | 21 |
| 17 | 6·21 | 30·85 | 13 (?) | 27·5 | ? | 18 (?) |
| 5 | 5·64 | 30·50 | 9 (?) | 28·0 | ? | 15 (?) |

An important feature of the results is the generally low protein content. Of the thirty-one samples, only five had a protein content approximating that given for "good" meadow hay in the published figures (9·7 per cent). One of these (No. 13) was obtained from outside the area, from a district purporting to have a reputation for good class hay. The sample obtained was classed as "good" by the farmer although he considered that it had suffered somewhat in the making that season. It is worthy of comment that the two really "good" samples from the district were regarded as the best obtainable on the respective farms, consistent with economic management. A number of samples falling below this standard were regarded as "good" on some of the farms.

As a result of the analyses and the method adopted of interpreting them it has been possible to revise the opinion held by farmers of the feeding value of some of their samples of hay and they have been ready to adopt the suggestion of earlier hay-making with a view to improving the feeding value of their hay. One example may serve to illustrate the good influence of the advisory comments which it was possible to make as a result of the analyses. In the first season it was found that the starch equivalent figure adopted

by a farmer for his hay in compiling his rations was considerably above the presumptive starch equivalent indicated by the analysis. In order to correct the calculated deficiency in the rations it was found good economy to spend £50 upon additional concentrates for winter feeding of a herd averaging twenty-six cows. The following season the hay was of much improved quality and it was possible to reduce the rations by 1½ lb. of concentrates per head per day.

The chief objectives of the work have been set out above under four heads and a summing up of the results with reference to those points is made below.

1. An empirical method was decided upon and adopted for the calculation of a " presumptive starch equivalent " of hay based on the determination in the laboratory of protein and fibre content.

2. Information was supplied to farmers upon their samples based upon this calculation enabling them to adjust their feeding plan accordingly.

3. There appears to be a general tendency in Kent and Surrey to estimate the feeding value of the better samples of hay grown locally above their probable value as suggested by the analysis.

4. It is, unfortunately, impossible to observe the specific effect of modifying rations on the farm sufficiently accurately to justify any emphatic statement putting forward the empirical method adopted as the best that can be devised.

The method has nevertheless proved a means of meeting the need for a more accurate appreciation on the farm of the feeding value of hay and this has proved a service which has been definitely appreciated by farmers.

# THE RELATIONSHIP OF HERBAGE TO SOIL IN ROMNEY MARSH

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One of the most striking conclusions of Cole and Dubey (1932) from their soil survey work in Romney Marsh was the fact that pasture fertility in that area was directly related to soil-profile. Using the soil-profiles in the Marsh the soils were classified by the American system into " soil series ", nine of which have been described as occurring in Romney Marsh. Many of the soils differ very much from one another and from a superficial examination of two very different soil series, such as Finn and Lydd, it is obvious that there is a corresponding difference of flora. This comparison is an extreme case ; it was, however, felt that there might be correlations between the flora and soil series in cases where the soils were more alike. Where the degree of fertility of pastures is peculiar to a certain soil series, it must be connected with the particular plant species upon those pastures, with the habit of growth of those species, or with a combination of plant species with habit of growth.

I have studied the herbage on three of the soil series which were shown to provide the three most fertile types of pasture. Two of these, the Finn and New Romney soil series provide two grades of the well-known " fatting " type of pasture on Romney Marsh. The Finn provides the finest pastures which fatten up to twelve sheep per acre, and the New Romney has the second grade pastures which fatten up to ten sheep per acre. The third soil series, Hurst, provides a " breeding " type of pasture which is non-fatting, and which carries from four to six sheep per acre.

In Romney Marsh climate and topography are almost uniform, and so is the system of management. Differences of drainage and soil acidity are factors well known for the way in which they influence plant species, and these are considered in establishing soil series. Messrs. Cole and Dubey have noted that in Romney Marsh a second period of growth starts in August and reaches a peak in September. All my observations were made during this period, i.e. at the end of August or during September. It might be expected that pastures which maintained a uniform fertility for a number of years would remain uniform in herbage characteristics, at the same season from year to year, but as a precaution a field examined in 1933 was again examined in 1934, in both cases at the end of August, and no marked differences were found. Details of these examinations are given in the discussion on Finn Field I.

To find out whether there was any relationship between the soil series and the botanical composition of the herbage, five fields each of Finn and Hurst soils and six fields of New Romney soil were studied. The localities were widely chosen and ranged from Burmarsh to Brookland and Lydd.

## Method of Botanical Analysis.

The botanical analysis of each pasture was made by a variety of " The Percentage Area Method " (Symposium, 1933). The productivity method, or removal of herbage, used by earlier workers in Romney Marsh (see Hall and Russell, 1912) has been criticized (Symposium, 1932), and the authors themselves have stated that such a method leads

to an undervaluation of Wild White Clover, and presumably of other plants of mat-like growth.

The " Percentage Tiller Estimation Method " presents difficulties where plants other than grasses are encountered, and even where grasses occur, the value of a tiller or shoot of such a grass as Fine-leaved Sheep's Fescue does not correspond with one of Cock's-foot or Timothy.

The writer has used the " Percentage Area Method " for several years and has found that it gives a very close interpretation of the herbage of a field. The technique of the method is as follows :

A plan of the field is made, and ten approximately equal areas are charted on it ; these areas are referred to as blocks. In each of these blocks a quadrat or square frame, measuring 6 by 6 inches is thrown at random ten times. At each throw the herbage is estimated within the quadrat thus : the area covered by each plant species is expressed as a proportion of ten square units. If, for example, Perennial Rye-grass covers half the area of the quadrat, then the figure is 5·0 for that throw. The degree of accuracy observed is to the nearest half unit of the quadrat area, i.e. 0·5. If a species occupies an area of less than a half unit (0·5) it is recorded as a " trace " and considered to be of a value approximating to 0·2. The summation of readings for the ten throws in one block thus gives a percentage area value for each species found in that block.

In addition to this area estimation the average height within each quadrat is measured to the nearest centimetre. The percentage area of the herbage components for the field is calculated from the average of the summation of the ten block readings, and the statistical analysis shows that the standard errors of this average are very satisfactorily low. Among the advantages of making observations in separate blocks are these : the uniformity of a pasture can be estimated ; the distribution of its component species can be examined throughout the field ; and differences in herbage in any particular part may be further investigated. An example of this last advantage is shown in the results for New Romney Field IV.

Unfortunately the method is not rapid, every tiller in the quadrat has to be examined because some grasses occur in very small quantities. The piecing together or summation of areas of different groups of the same species in a quadrat cannot be very hurriedly done however practised the observer may become. Hall and Russell (1912) stated that the only difference between the herbage on " fatting " and " non-fatting " pastures was that of growth habit and that the species and quantity of species were similar. Partly for this reason the large number of observations referred to above was made on each field, as it was necessary to have a particularly true and accurate analysis.

The growth habit has been especially noted. The differences are not entirely a matter of leaf : stem ratio, but a contrast between a larger number of small, densely-packed upright tillers, each producing its quota of leaves, and coarser, larger and spreading tillers, which are fewer in number in the same area.

A rapid method of gauging this quality was made by a simple scale as (*a*) tillers very densely packed, (*b*) tillers well packed, (*c*) tillers moderate in number, (*d*) tillers few in number.

## RESULTS.

The fields on each soil series are first of all considered separately, and then the results are grouped to show the connexion between the soil and the flora.

TABLE I.

*Finn Soil Series.*

| | Field I. 1932. | | Field I. 1933. | | Field II. | | Field III. | | Field IV. | | Field V. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Percentage area. | Standard error. | Percentage area. | Standard error. | Percentage area. | Standard error. | Percentage area. | Standard error. | Percentage area. | Standard error. | Percentage area. | Standard error. | Average Percentage area. |
| *Lolium perenne* L., Perennial Rye-grass | 78·4 | 2·0 | 75·9 | 1·5 | 73·2 | 1·3 | 77·1 | 2·0 | 65·5 | 1·8 | 75·8 | 1·1 | 74·0 |
| *Agrostis vulgaris* With., Bent-grass .. | 3·2 | 0·7 | 5·8 | 0·9 | 7·2 | 1·0 | 8·4 | 1·2 | 12·0 | 1·3 | 8·3 | 0·9 | 7·8 |
| *Trifolium repens* L., Wild White Clover | 9·7 | 0·7 | 10·3 | 1·1 | 10·0 | 0·9 | 5·7 | 0·4 | 9·0 | 0·8 | 10·3 | 0·7 | 8·9 |
| *Holcus lanatus* L., Yorkshire Fog .. | 3·2 | 1·0 | 2·3 | 0·8 | 1·3 | 0·8 | 4·9 | 1·2 | 9·2 | 1·6 | 1·7 | 0·6 | 4·1 |
| *Poa trivialis* L., Rough-stalked Meadow-grass .. .. .. .. .. | 5·3 | 0·4 | 4·9 | 0·8 | 5·6 | 0·4 | 2·5 | 0·4 | 2·4 | 0·3 | 2·6 | 0·3 | 3·7 |
| *Cynosurus cristatus* L., Crested Dog's-tail .. .. .. .. .. | 1·0 | 0·3 | 1·4 | 0·2 | 3·8 | 0·4 | 2·0 | 0·2 | 2·7 | 0·4 | 2·5 | 0·2 | 2·4 |
| Moss .. .. .. .. .. | Trace | | 0·2 | | 0·1 | | 0·1 | | 0·4 | | 0·2 | | 0·1 |
| *Avena flavescens* L., Golden Oat .. | Trace | | 0·1 | | 0·2 | | 0·2 | | 0·1 | | 0·4 | | 0·2 |
| *Miscellaneous species .. .. .. | 0·1 | | 0·2 | | 0·9 | | 1·4 | | 1·0 | | 0·5 | | 0·8 |
| Average height in centimetres .. | 3·3 | | 2·3 | | 2·6 | | 3·3 | | 3·3 | | 3·0 | | |

* There were twelve other species of which not one was present in all five fields, and in every case in quantities of less than an average of 0·5 per cent: *Festuca ovina* L., Sheep's Fescue. *Bellis perennis* L., Daisy. *Hordeum pratense* Huds., Meadow Barley. *Dactylis glomerata* L., Cock's-foot. *Achillea millefolium* L., Yarrow. *Cerastium vulgatum* L., Mouse-ear Chickweed. *Rumex Acetosa* L., Sorrel. *Poa pratensis* L., Smooth-stalked Meadow-grass. *Lotus corniculatus* L., Bird's-foot Trefoil. *Trifolium pratense* L., Red Clover. *Ranunculus repens* L., Creeping Buttercup. *Phleum pratense* L., Timothy.

## I. FINN SOIL SERIES.

### Finn Field I.

Date of analysis, 29 August 1932.

This field has the reputation of being one of the finest in Romney Marsh, the even character of the well-grazed sward and its manner of growth are very striking.

Table I shows that the flora is very restricted, six species only are uniformly present, and of these Perennial Rye-grass (78·4 per cent) and Wild White Clover (9·7 per cent) make up the bulk of the herbage. The percentage areas for the individual blocks indicate the even distribution of certain species throughout the field. Perennial Rye-grass shows particularly little deviation from an average, and this is emphasized in the calculation for the standard error. Wild White Clover and Rough-stalked Meadow-grass are also evenly distributed, but Yorkshire Fog occurs only in certain blocks ; these are principally at one side of the field, whereas at the opposite side Yorkshire Fog is either absent or present only in very small quantities ; this may be due to chance infestation, or to a factor at present unknown. As this field is one of the most famous for its fertility and quality, it is evident that the species recorded must when taken as a whole, be of high nutritive value, and it is interesting to note that Bent-grass, *Agrostis vulgaris* With. is now recognized as valuable in a sward of high quality if it is kept heavily grazed (Symposium, 1932). The continuous heavy grazing of this field prevents the Yorkshire Fog from becoming a large, coarse, hummocky grass, in which condition it is such a pronounced weed as to be officially scheduled.

The habit of growth of the grasses is very luxuriant, a " springy " character is imparted to the turf by the densely-packed tillers, noted chiefly in the Perennial Rye-grass.

The herbage certainly comes under group (*a*) of the scale, i.e. tillers very densely packed.

The results for Field I, 1933, indicate a very similar herbage on the same field measured a year later. It had been grazed a little more closely at the time of the analysis, but the distribution of the grasses throughout the field is very like that of the previous estimation, and it is interesting to note that the highest value for Yorkshire Fog occurs in the same block as before.

Slight differences are that the trace of Meadow Barley observed in 1932 is not included in any of the quadrats in 1933, but is noted as occurring in the field, and Mouse-ear Chickweed, present in sufficient quantity to be estimated as covering 0·1 per cent of the field in 1933, had only been noted as occurring in a small quantity in 1932 outside the quadrat estimations.

A few clumps of *Urtica dioica* L., Common Nettle, are also present, but not in sufficient quantity to fall in any of the hundred random throws of the quadrat. The practically identical composition of the herbage for the two years indicates that further fields examined in the second year might reasonably be compared with those examined in the first.

### Finn Field II.

Date of analysis, 7 September 1932.

The blocks could not be charted in such a regular manner as in Field I, as an area occupied by poultry, ponds and some remains of old dykes had to be avoided.

The species present and their percentage areas are very much the same as in Field I, and the same type of distribution is evident. Yorkshire Fog in any quantity occurs only in two blocks at one end of the field. The even distribution of the small percentages of Bent-grass, Rough-stalked Meadow-grass and Crested Dog's-tail is again very striking, and the few species and small percentages present of miscellaneous plants compare very closely with the first field described.

The same type of growth of the turf was noted on this field as on Field I, the densely-packed tillers place it in the (*a*) group. It is in a different part of the Marsh, and is considered one of the best pastures in its locality.

FINN FIELD III.

Date of analysis, 24 August 1933.

At one side is an area with a very rough ungrazed herbage consisting of Rushes, Meadow Barley, Bent-grass and Yorkshire Fog. It contains a spring and surrounds some sheds. The area on which the blocks were taken is very different as it consists of a well-grazed, even sward. The average percentage areas of the plants shows close analogies with Fields I and II. Perennial Rye-grass constitutes the same large proportion of the herbage, and Wild White Clover gives a percentage quite close to the others although it is the smallest for this species in any of the Finn fields. A typical Finn type of growth was noted, i.e. the tillers of the grasses, particularly of Perennial Rye-grass, were densely packed.

FINN FIELD IV.

Date of analysis, 25 August 1933.

This is a smaller field than the previous ones, level, with an even sward.

Perennial Rye-grass gives a little lower figure (65·5 per cent), its place is evidently occupied by Yorkshire Fog and Bent-grass, both of which give the highest figures for the fields of this series examined (9·2 and 12·0 per cent respectively).

Wild White Clover corresponds closely with the proportion in other Finn fields, and Crested Dog's-tail and Rough-stalked Meadow-grass occur in the same small proportion and even manner as on the previous fields. The number of species present is remarkably small. Their habit of growth compares closely with that on other fields of this series.

FINN FIELD V.

Date of analysis, 28 August 1933.

The field is very level, has an even sward, and shows a very similar analysis to that of the first four fields. The figures giving the percentage areas in the blocks show the remarkable uniformity of herbage throughout the field for the majority of plant species. Yorkshire Fog is again an exception, showing an irregular distribution which is perhaps characteristic of it.

The same type of growth occurs on this field as on the others. The pasture closely approaches the excellence of Field I, but the slightly higher percentage of Bent-grass (8·3 per cent) would not be quite so satisfactory. This field, in quite a different locality to Field I, has a great reputation locally, and is there considered to be the finest in the Marsh. Several fields have this reputation and it is interesting to note that they all occur on the Finn soil series.

# TABLE II.

*New Romney Soil Series.*

| | Field I. | | Field II. | | Field III. | | Field IV. | | Field V. | | Field VI. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Average Per-centage area. |
| *Lolium perenne* L., Perennial Rye-grass | 46·2 | 4·8 | 59·8 | 3·9 | 51·1 | 5·1 | 52·4 | 1·1 | 70·0 | 2·7 | 56·1 | 2·8 | 55·9 |
| *Agrostis vulgaris* With., Bent-grass .. | 21·7 | 2·8 | 7·4 | 0·7 | 12·4 | 1·2 | 19·2 | 1·4 | 6·5 | 0·9 | 14·1 | 1·4 | 13·6 |
| *Trifolium repens* L., Wild White Clover | 2·7 | 0·5 | 7·5 | 0·7 | 5·6 | 1·2 | 4·5 | 0·3 | 3·9 | 0·7 | 6·4 | 0·6 | 5·1 |
| *Holcus lanatus* L., Yorkshire Fog .. | 21·2 | 4·0 | 3·6 | 0·6 | 18·8 | 3·9 | 12·8 | 1·4 | 4·9 | 1·3 | 12·6 | 2·3 | 12·3 |
| *Poa trivialis* L., Rough-stalked Meadow-grass .. .. .. .. .. | 5·1 | 0·8 | 2·7 | 0·5 | 5·0 | 0·9 | 4·0 | 1·0 | 9·7 | 0·8 | 4·8 | 0·7 | 5·2 |
| *Cynosurus cristatus* L., Crested Dog's-tail .. .. .. .. .. | 1·1 | 0·2 | 7·6 | 1·4 | 1·0 | | 3·8 | 0·4 | 0·6 | | 6·8 | 1·2 | 3·5 |
| *Festuca ovina* L., Sheep's Fescue .. | 0·4 | | 5·7 | 1·3 | 1·9 | 0·8 | — | | 0·3 | | — | | 1·4 |
| *Bellis perennis* L., Daisy .. .. | 0·1 | | 3·1 | 0·8 | — | | 0·8 | | — | | — | | 0·7 |
| *Hordeum pratense* Huds., Meadow Barley .. .. .. .. | 0·2 | | 0·2 | | — | | 0·1 | | Trace | | 0·2 | | 0·1 |
| *Dactylis glomerata* L., Cock's-foot .. | — | | 1·7 | 0·9 | 0·2 | | — | | 0·8 | | — | | 0·5 |
| Moss .. .. .. .. .. | 0·1 | | 0·4 | | 0·1 | | 1·0 | | — | | Trace | | 0·4 |
| *Achillea millefolium* L., Yarrow .. | 0·5 | | 1·4 | | 0·6 | | — | | 3·4 | 1·4 | Trace | | 1·0 |
| *Avena flavescens* L., Golden Oat .. | Trace | | 1·1 | | 0·3 | | 0·2 | | 0·1 | | 0·8 | 0·1 | 0·4 |
| *Cerastium vulgatum* L., Mouse-ear Chickweed .. .. .. .. | 0·4 | | 0·2 | | 0·6 | | 0·8 | | 0·3 | | 0·2 | | 0·4 |
| *Rumex Acetosa* L., Sorrel .. .. | 0·9 | | 0·3 | | 0·9 | | 0·4 | | 0·4 | | Trace | | 0·5 |
| *Poa pratensis* L., Smooth-stalked Meadow-grass .. .. .. | 0·8 | | 0·4 | | 1·1 | | — | | 0·5 | | — | | 0·5 |
| *Miscellaneous species .. .. .. | 1·3 | | 0·2 | | 2·9 | | 2·6 | | — | | 0·1 | | 1·2 |
| Average height in centimetres .. | 5·5 | | 2·6 | | 6·7 | | 3·6 | | 3·3 | | 4·8 | | |

* There were thirteen other species of which not one was present in all six fields, and in every case quantities of less than an average of 0·5 per cent.: *Carduus arvensis* Robs., Creeping Thistle. *Lotus corniculatus* L., Bird's-foot Trefoil. *Leontodon autumnalis* L., Autumnal Hawkbit. *Prunella vulgaris* L., Self-heal. *Trifolium pratense* L., Red Clover. *Ranunculus repens* L., Creeping Butter-cup. *Carex* sp., Sedge. *Potentilla reptans* L., Cinquefoil. *Anthoxanthum odoratum* L., Sweet Vernal-grass. *Bromus arvensis* L., Field Brome-grass. *Juncus* sp., Rush. *Phleum pratense* L., Timothy. *Potentilla Anserina* L., Silverweed.

## II. NEW ROMNEY SOIL SERIES.

New Romney Field I.

Date of analysis, 1 September 1932.

The analyses given in Table II indicate the differences between New Romney and Finn soils. The chief ingredient is again Perennial Rye-grass but in a considerably smaller proportion (46·2 per cent). The remainder is largely composed of about equal percentages of Bent-grass and Yorkshire Fog (21·7 per cent and 21·2 per cent respectively). The individual block analyses show that Bent-grass occurs consistently although in somewhat varying proportions throughout, whereas Yorkshire Fog, although present in each block, varies a very great deal in its proportion, ranging from 2 per cent to 43 per cent.

Rough-stalked Meadow-grass occurs again in a fairly regular although small proportion throughout. The small percentage of Wild White Clover (2·7 per cent) is very different from the higher figures in the Finn fields. A larger number of species than was customary in the Finn fields forms the remaining small proportion. Of these, the presence of Sorrel indicates an acid soil reaction which is typical of the New Romney series. Yarrow occurs more prominently in some parts of the field than in others.

Comparatively few constituents of the herbage remain unlogged after the analysis; in this field a few plants of *Carduus arvensis* Robs., Creeping Thistle, *Ranunculus acris* L., Upright Buttercup, and *Urtica dioica* L., Common Nettle are to be observed. This herbage is a little longer than in the majority of those examined, and longer than it is usually, as less sheep were folded in 1932, a reflection of the economic situation with respect to sheep in that year.

The growth of the herbage is not as luxuriantly dense as on the previous Finn fields, but in places the Perennial Rye-grass tillers exceedingly well, and generally the tillering is of the class (*b*) type.

New Romney Field II.

Date of analysis, 14 September 1932.

The field slopes at one end and at the edge of this lower part of the field are rough ungrazed patches consisting of Fiorin, Cock's-foot, Yorkshire Fog, Meadow Barley and Common Horse-tail. Other small areas contain Common Nettle.

It is evident that the soil or the water-table is entirely different in these places and they contrast very much with the even and well-grazed typical New Romney sward on which the analysis is made.

The analysis indicates the good quality of the herbage typical of the high grading of pastures on this soil. In this field the analysis also shows why the pasture performance does not quite equal that of a well-managed Finn field. Perennial Rye-grass covers 14 per cent less than in an average Finn field, and there is an increase in both percentage area and in number of miscellaneous species. Daisy is a very prominent weed, and although such constituents as Yarrow and Golden Oat are considered to be favourable, they would not produce such continuous good feeding value as Perennial Rye-grass. Sorrel reminds one again that this soil frequently possesses an acid reaction.

Comparison of the analyses for the separate blocks shows the deleterious effect of having a weedy area anywhere near a pasture—a point which is not so fully appreciated as it is when such an area adjoins arable land. Those blocks nearer the ungrazed rough areas referred to, have a higher percentage of miscellaneous species in place of the Perennial Rye-grass than in the remaining blocks in the field. Meadow Barley, Mouse-ear Chickweed, Sorrel, Moss and Golden Oat are more prominent on these particular blocks.

The very important habit of growth varies from class (*b*) to class (*a*), the Perennial Rye-grass showing the spongy dense closely-packed tillers of class (*a*) in some parts. The height figures indicate how well-grazed this field was.

NEW ROMNEY FIELD III.

Date of analysis, 28 September 1933.

This field is small and level, but with rather uneven herbage. The northern half of the field shows a general infestation of Rushes, whereas the southern half shows considerably fewer, except on a small area around a pond.

Rushes often occur where there is a high water-table, and it is interesting to note that a markedly high water-table was observed in this field.

The analysis of the field shows a flora typical of a New Romney soil. A comparatively low percentage of Perennial Rye-grass (51·1 per cent) is unfavourably compensated by the high percentage of Yorkshire Fog (18·8 per cent). Sorrel is again present. Silverweed often occurs where there is a high-water table, especially on this soil series, as has been noted in surveys on arable fields. The presence of small quantities of Creeping Buttercup, Self-heal and Mouse-ear Chickweed indicate the danger that this field might lose its " fatting " qualities if it were not closely grazed. During the season prior to the analysis, fewer sheep than usual have been grazed on it on account of the economic position, and as a consequence the herbage is unduly long for such a first-class pasture. The average height is 6·7 cm.

NEW ROMNEY FIELD IV.

Date of analysis, 28 August 1933.

The field is somewhat rough in character owing to the tufted nature of much of the grass, with the exception of one end which is more evenly grazed. As no soil surveyor was available at the time to confirm the uniformity of the soil of this field the analysis was made all over it, avoiding, of course, a depression filled with a large colony of Silverweed. The figures obtained for eight blocks indicate a very uniform herbage, reflected in the standard errors being particularly low. The end of the field which was more evenly grazed is covered by two blocks. This shows a different analysis. The first eight blocks give a typical New Romney herbage ; Perennial Rye-grass (52·4 per cent), Bent-grass, Yorkshire Fog, Sorrel and other miscellaneous species correspond closely with the other New Romney pastures. The growth of the grass is of the class (*b*) type. The end of the field covered by the two blocks gives a typical Finn herbage. A high percentage of Perennial Rye-grass (average 72 per cent), a very small amount of Yorkshire Fog (average 0·3 per cent) which is entirely absent in one of the blocks, no Sorrel and a much more restricted flora, suggested a soil difference from the rest of the field. Mr. L. W. Cole very kindly investigated this area, and his borings on these two blocks confirmed the suggestion that the soil belonged to the Finn soil series.

This was an interesting case of the botanical analysis indicating a difference of soil series in a pasture which was of " fatting quality " grade throughout. The average percentage areas of the species in this field are therefore calculated from the analysis of the eight blocks.

New Romney Field V.

Date of analysis, 31 August 1933.

This is a very well-managed field in good condition. It gives an unusually high percentage of Perennial Rye-grass (70·0 per cent). Wild White Clover (3·9 per cent) a small percentage, typical of New Romney herbage. Yarrow and Sorrel also indicate a New Romney soil rather than a Finn. A slope towards one end of the field made no difference in the herbage. An unusually small amount of Crested Dog's-tail (0·6 per cent) is present, its place being taken by a comparatively large percentage of Rough-stalked Meadow-grass (9·7 per cent). The irregular distribution of Yorkshire Fog is again apparent in this field.

New Romney Field VI.

Date of analysis, 21 September 1932.

This is a very well-managed field with an even sward. It gives an analysis which is very close to the average on New Romney soils. Perennial Rye-grass, for example, covering 56·1 per cent compares closely with 55·9 per cent which is the average of the first five fields described for this soil.

The botanical analysis for the north part of the field indicates that the soil may be slightly heavier and nearer to the Finn.

Silverweed, often associated with New Romney soils as indicated before, is present along the south edge of the field.

The grasses in this field are well tillered, chiefly of the class (*b*) group with some densely tillered plants of the class (*a*).

## III. HURST SOIL SERIES.

Hurst Field I.

Date of analysis, 2 September 1932.

Except for a rough area on one side, which was avoided in the analysis, and two depressions which were once ditches, the field is level and uniform in character. The analysis gives a high percentage of Perennial Rye-grass (69·7 per cent), a good figure for Wild White Clover (8·6 per cent), and an entire absence of Yorkshire Fog. This might indicate a performance comparable with the best pastures on the Finn soils were it not for the fact that the habit of growth of the grass is entirely different. In this case the grass is more spreading with fewer tillers, and although covering the ground well, it does not give the same bulk, and is placed in the (*c*) type.

## Table III.

*Hurst Soil Series.*

| | Field I. | | Field II. | | Field III. | | Field IV. | | Field V. | | |
|---|---|---|---|---|---|---|---|---|---|---|---|
| | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Per-centage area. | Stan-dard error. | Average Per-centage area. |
| *Lolium perenne* L., Perennial Rye-grass | 69·7 | 2·4 | 66·3 | 1·9 | 50·8 | 1·5 | 33·6 | 2·2 | 57·1 | 1·1 | 55·5 |
| *Agrostis vulgaris* With., Bent-grass | 12·5 | 2·4 | 9·8 | 0·8 | 18·2 | 1·4 | 17·4 | 2·2 | 10·0 | 1·0 | 13·6 |
| *Trifolium repens* L., Wild White Clover | 8·6 | 0·7 | 6·8 | 0·7 | 7·8 | 0·6 | 11·9 | 1·2 | 14·4 | 0·7 | 9·9 |
| *Holcus lanatus* L., Yorkshire Fog | — | | — | | 0·3 | | 8·4 | 0·8 | 0·1 | | 1·8 |
| *Poa trivialis* L., Rough-stalked Meadow-grass | 3·1 | 0·4 | 4·3 | 0·4 | 2·7 | 0·3 | 1·7 | | 4·5 | 0·5 | 3·3 |
| *Cynosurus cristatus* L., Crested Dog's-tail | 2·9 | 0·3 | 4·8 | 0·7 | 6·6 | 0·8 | 2·4 | 0·3 | 6·6 | 0·7 | 4·7 |
| *Festuca ovina* L., Sheep's Fescue | — | | Trace | | 3·3 | 1·5 | 7·2 | 1·0 | 0·1 | | 2·1 |
| *Bellis perennis* L., Daisy | 1·6 | 0·4 | 3·9 | 0·7 | 2·4 | 0·6 | 2·4 | 0·8 | 3·1 | 0·6 | 2·7 |
| *Hordeum pratense* Huds., Meadow Barley | 0·6 | | 1·8 | | 4·0 | 0·5 | 4·3 | 0·6 | 0·4 | | 2·2 |
| *Dactylis glomerata* L., Cock's-foot | 1·3 | 0·6 | 2·7 | 0·4 | 1·1 | | 0·9 | | 2·7 | 0·8 | 1·7 |
| Moss | 1·7 | 0·8 | 0·8 | | 1·5 | 0·3 | 1·1 | | 1·2 | | 1·3 |
| *Avena flavescens* L., Golden Oat | 0·1 | | 1·9 | | 1·3 | 0·2 | 0·4 | | 0·5 | | 0·8 |
| *Carduus arvensis* Robs., Creeping Thistle | — | | — | | 0·2 | | 4·3 | 1·0 | — | | 0·9 |
| *Cerastium vulgatum* L., Mouse-ear Chickweed | 0·2 | | 0·4 | | 0·1 | | 0·2 | | 0·1 | | 0·2 |
| *Lotus corniculatus* L., Bird's-foot Trefoil | 0·3 | | 0·2 | | 0·8 | | 2·3 | 0·9 | — | | 0·7 |
| *Miscellaneous species | 0·3 | | 0·5 | | 2·7 | | 3·5 | | 1·7 | | 3·0 |
| Average height in centimetres | 2·6 | | 3·1 | | 3·5 | | 3·4 | | 2·4 | | |

* There were eighteen other species of which not one was present in all five fields, and in every case in quantities of less than an average of 0·5 per cent: *Rumex Acetosa* L., Sorrel. *Poa pratensis* L., Smooth-stalked Meadow-grass. *Leontodon autumnalis* L., Autumnal Hawkbit. *Prunella vulgaris* L., Self-heal. *Trifolium pratense* L., Red Clover. *Ranunculus bulbosus* L., Bulbous Buttercup. *Ranunculus repens* L., Creeping Buttercup. *Carex* sp., Sedge. *Potentilla reptans* L., Cinquefoil. *Bromus arvensis* L., Field Brome-grass. *Phleum pratense* L., Timothy. *Plantago lanceolata* L., Ribwort Plantain. *Agrostis alba* L. var. *stolonifera*, Fiorin. *Alopecurus pratensis* L., Meadow Foxtail. *Carduus lanceolatus* L., Spear Thistle. *Festuca ovina* L. var. *duriuscula* Koch, Hard Fescue. *Hieracium Pilosella* L., Mouse-ear Hawkweed. *Medicago lupulina* L., Black Medick. Of bare ground there was, also, always less than 0·5 per cent.

The species present, other than those mentioned, show differences when compared with the Finn soils, for a larger number occur, and the percentage areas occupied by these miscellaneous species are greater than in the Finn examples. Moss (1·7 per cent), and Daisy (1·6 per cent), indicate the heaviness of the soil, typical of the Hurst series. Meadow Barley, widespread in small quantities, is a particularly bad weed as the sharp points of the "seeds" cause trouble in the feet of the sheep-dogs and also in the mouths of the sheep.

This pasture is very well grazed, the average height being 2·6 cm.

HURST FIELD II.

Date of analysis, 8 September 1932.

This is a level field with occasional clumps of Common Nettle giving a herbage which would be of very different value if the soil beneath belonged to the Finn series. Perennial Rye-grass (66·3 per cent), Wild White Clover (6·8 per cent), absence of Yorkshire Fog and Bent-grass in moderate proportions again indicate great possibilities, but the growth is similar to that of the first Hurst field, i.e. tillering is poor and is of the (*c*) type. The miscellaneous species again show differences from a Finn herbage. Daisy is the worst weed, occupying 3·9 per cent of the area. Meadow Barley and Moss are also characteristic. Cock's-foot occurs throughout this pasture in small proportions (2·7 per cent).

HURST FIELD III.

Date of analysis, 27 September 1932.

This is a large field with occasional colonies of Rushes.

Perennial Rye-grass is not as widespread as in the first two fields described on this soil; it occupies 50·8 per cent of the area. Bent-grass covers a greater area (18·2 per cent), than in the other two fields, and there is a long list of miscellaneous constituents. Meadow Barley (4 per cent), and Daisy (2·4 per cent), are widespread weeds. Many of these miscellaneous constituents have a considerable herbage value and must not be considered as weeds. Sheep's Fescue (the fine-leaved variety), Golden Oat, often praised for its early spring growth, in the summer appears to have little nourishment in its rather narrow slender blades on these pastures, Cock's-foot, Bird's-foot Trefoil, Timothy and Red Clover, only noted occasionally, are all of value.

The same (*c*) type of growth is again noted in this field.

HURST FIELD IV.

Date of analysis, 28 September 1933.

This is a level, even field which produces the smallest percentage of Perennial Rye-grass (33·6 per cent), of any of the fields examined. Bent-grass (17·4 per cent), is the species with the next highest percentage, and the remainder is composed of a large number of constituents. Meadow Barley (4·3 per cent), had caused particular trouble on this field in the manner described for Field I of this series. Creeping Thistle (4·3 per cent), is widespread throughout the field, and Daisy, Moss and Cinquefoil are other prominent weeds.

The grass is far from luxuriant, and is well flattened out with few tillers although the ground is well covered, the tillering is of the (*c*) type.

HURST FIELD V.

Date of analysis, 29 September 1933.

On one side of this field is a very rough area with Fiorin, quite different in character from the remainder. The blocks are charted on the part known to be on the Hurst soil series. Perennial Rye-grass (57·1 per cent) covers a satisfactory area and the Wild White Clover (14·4 per cent) gives a high yield throughout the field.

Daisy (3·17 per cent), and Moss (1·2 per cent), indicate a heavy type of soil. Bulbous Buttercup occurs in small but regular proportions throughout the field, whereas Autumnal Hawkbit occurs less frequently but occupies a larger area when present.

The growth is of the (*c*) type, similar to the other Hurst pastures.

## GENERAL CONCLUSIONS.

Tables I, II and III give the average percentage areas of the members of the flora of each complete field grouped according to the soil, so that comparisons may be made quite easily. The herbage constituents in the left hand column of the Tables have been arranged in order of total quantity present in all the fields.

The character of the herbage on the three soil series, FINN, NEW ROMNEY and HURST, are considered from the following points of view: (i) The constituent species. (ii) The percentage area covered by individual species. (iii) The growth habit of the herbage.

I. FINN SOIL SERIES. (Table I.)

The most interesting of the Romney Marsh pastures are found on this soil series, as they are of the highest grade of pasture performance. The fields showed a uniform type of herbage, the bulk of which is composed of Perennial Rye-grass with an average area of 75 per cent. Wild White Clover 9 per cent, and Bent-grass 8 per cent, occurred as the next important constituents, although in the field with the greatest reputation the latter was only 3 per cent of the area.

Yorkshire Fog, well grazed in these well-managed pastures, was a species common to all the Finn fields in the small proportion of 4 per cent. The very local or irregular distribution of this grass has been stressed.

Rough-stalked Meadow-grass covered the same proportion, 4 per cent, as Yorkshire Fog, but its even or regular distribution throughout the whole of the pastures formed a marked contrast. Crested Dog's-tail was another regular and evenly distributed component covering an average area of 2·5 per cent. The remaining species found, each less than 0·2 per cent of the area, were chiefly remarkable for their small number. There was an absence of many of the weeds found commonly on pastures of a poorer grade.

The third point of view of the herbage, that of the habit of growth, has been discussed, and it is quite evident that the grasses form a denser sward on this soil series than on either of the others considered.

II. New Romney Soil Series. (Table II.)

The pastures on this soil although of " fatting " grade are ranked second in quality to those on Finn soils.

The herbage showed distinct differences. There was a considerable drop in the percentage of Perennial Rye-grass on all the fields except one ; the average area was 56 per cent. Yorkshire Fog covered about three times the area of an average field on this soil compared with an average Finn field, and Bent-grass in the majority of the fields covered about twice the area.

Rough-stalked Meadow-grass and Crested Dog's-tail showed similar proportions to those on the Finn soils.

There was a definite increase in the number and percentage figures for the miscellaneous species, some of which may be considered as valuable.

Sheep's Fescue and Yarrow were fairly regular constituents of value, although they occupied under 2 per cent of the area of an average field.

Daisy, Moss, Sorrel, Mouse-ear Chickweed, Sedge, Creeping Buttercup, Self-heal and Silverweed were some of the examples of the miscellaneous species which were more prominent on these soils than on the Finn. The presence of these would suggest that any decrease in the normal number of sheep per acre would be reflected in a quicker deterioration of these pastures, because these miscellaneous species would then increase to much larger proportions and there would be a consequent diminution of grazing value. The growth of the herbage was more difficult to gauge—in most cases the grasses were tillered very well, but not quite so densely as those on the Finn soils.

III. Hurst Soil Series. (Table III.)

The Hurst soils, while providing some of the best pastures of the " breeding " grade, fall considerably below the "fatting" type typical of the two former soil series. The Perennial Rye-grass varied in these fields considerably (34-70 per cent).

Bent-grass was in about the same proportion as in the fields on the New Romney soils, but Yorkshire Fog was practically absent from four out of the five fields examined.

Rough-stalked Meadow-grass and Crested Dog's-tail were as evenly distributed on these fields as on the others.

The miscellaneous species had increased in number and percentage, Daisy and Moss in particular were very common on all these fields.

Yarrow was absent in all cases, and Sorrel was present only in a small quantity in one case.

The growth, however, of the grasses was markedly different on this soil. The tillering was only moderate and instead of the compact, densely crowded, upright shoots they were spread out more and fewer in number.

The ground was well covered, but it was evident that the same bulk or weight of herbage would not be available for grazing. Although the extension of the plant species list and the higher percentage of many weeds indicated an inferior pasture the proportion of Wild White Clover was good, and the presence of a large percentage of Perennial Rye-grass suggests at first sight that these fields possess " fatting " possibilities. But

when the third variation, that of growth habit, is taken into consideration, it is realized that this must always prevent the development of " fatting " quality. Thus, although the required plant species may be present, the kind of soil may be an adverse limiting factor in the improvement of a pasture.

In conclusion the author wishes to thank Mr. L. W. Cole, Dr. J. K. Dubey and Dr. S. Graham Brade-Birks for their advice and information regarding the soils, Mr. H. B. Bescoby for his kind guidance in the statistical treatment of the results, and the several Marsh graziers who allowed the writer to examine their pastures.

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# AGRICULTURAL INVESTIGATIONS 1927-32

By H. B. Bescoby, N.D.A., P.A.S.I.
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## Introduction.

Agricultural trials have been carried out yearly on the College Farms and this report summarizes the work undertaken during the period 1927-32. The Agricultural Department has been responsible for the field trials and has worked in close co-operation with the other departments of the College and is indebted to them for technical advice and assistance.

## Field Trials.

The field trials carried out during the years 1927-30 were designed in duplicate or triplicate plots, the arrangement of the plots being systematic. In 1930 the introduction of statistical methods altered the design to the controlled randomized arrangements of Latin Squares and randomized blocks.

The value of field trials is often quite local owing to different soil and weather conditions; and so the trials on the College Farms have frequently been carried out as part of a larger series of trials including other parts of the country and have been instituted in conjunction with the Ministry of Agriculture, Rothamsted Experimental Station, the National Institute of Agricultural Botany, and the Institute of Brewing. The trials were repeated for two or more years to overcome seasonal factors. The results of the trials have been published in this *Journal* each year and are obtainable, upon application, from the Secretary of the College. When considering the results of trials it must be remembered that the College Farms are in a good state of fertility and therefore the application of artificial manures does not increase the yields to the same extent that would be expected on soils of a lower fertility.

## Barley.

*Quality.*—The trials on this crop have been largely concerned with the effect of the application of nitrogenous manures upon the nitrogen content of the grain. The nitrogen content of the grain is known to be of importance in the brewing process and the Rothamsted Experimental Station has undertaken trials to investigate the effect of nitrogenous manuring, this College assisting in these investigations. The results of the experiments showed that the application of nitrogenous manures had a tendency to increase the nitrogen content of the grain but when used in quantities giving the equivalent nitrogen to 1 cwt. of Sulphate of Ammonia per acre the increase was not materially large (Rothamsted Report for 1932, pp. 38-9). The application of mineral manures gave no consistent effect on the nitrogen content but on this farm the application of Salt gave a decreased nitrogen content.

*Yield.*—The application of nitrogen increased the yield of grain and straw when made under ordinary farming conditions. The application of mineral manures did not increase the yield.

The manures used were Sulphate of Ammonia, Nitrate of Soda, Calcium Cyanamide, Muriate of Ammonia and Ammonium Humate (Crowther and Brenchley, 1934). The phosphoric acid was supplied by Superphosphate and Potash by Muriate and Sulphate of Potash.

### Dusting of Barley Seed.

The barley on the College Farm had become badly infected with Leaf Net Blotch (*Helminthosporum teres*) and trials were carried out to control the disease. The seed grain was dusted with Ceresan, Agrosan and Mercuric Chloride dust. The effect of these treatments was to lessen the disease on the treated plots during the early stages of growth but as the season advanced all the plants became affected. It was therefore impossible to measure the effect of the disease on the yields of barley but as the average yield for the farm was between seven and eight quarters per acre, it does not appear that the disease was lowering the yield to any marked extent.

### Potatoes.

*Manuring.*—Series of trials have been carried out on the manuring of main crop potatoes and the results of these trials have been published (Bescoby, 1932). The conclusion was that the most economical manuring was 12 tons of farmyard manure, 4 cwt. of Superphosphate, 2 cwt. of Sulphate of Potash and 2 cwt. of Sulphate of Ammonia per acre, the last two manures being increased to 3 cwt. if the market price of potatoes was satisfactory.

*Varieties.*—Twelve varieties of potatoes were tested for yield and the three varieties which gave the heaviest yields were Arran Consul, Arran Banner and Seedling 675. These three varieties were grown for three years and tested against King Edwards as a control variety. The result each year was the same, the Arran Consul giving the heaviest yield with Arran Banner second. King Edwards consistently gave a low yield in comparison but the more ready sale and higher price of the King Edwards has to be considered.

*Virus Disease.*—At the request of Dr. Salaman special virus-free seed-potatoes were planted and gave a yield of 1 to 2 tons per acre more than seed from Scotland.

### Sugar-Beet.

*Manuring.*—In conjunction with the Rothamsted Experimental Station, trials to test the effect of nitrogenous manures and chlorides on the yield and sugar content of sugar-beet were carried out. Sulphate of Ammonia, Calcium Cyanamide, Muriate of Ammonia and Nitrate of Soda were used and in all cases increased the yields of roots and tops. The Nitrate of Soda gave the most satisfactory increases. Ammonium Humate did not increase the yields to the same extent as Nitrate of Soda or Sulphate of Ammonia. There was evidence that the sugar percentage was decreased by the application of nitrogenous manures.

Muriate of Potash and salt had little effect on the yield but there was an increase in the sugar percentage ; this result was not obtained at some of the other trial centres (Rothamsted Report for 1932, pp. 22-3).

### Kale.

The application of nitrogen as a top dressing to thousand-headed Kale usually increases the yield, but there was no increase when the Kale had been previously manured with farmyard manure and a complete dressing of artificials.

SWEDES.

The application of phosphates has increased the yield of swedes in some districts. Trials on this farm have given a small increase but not to any material extent.

MANGELS.

*Varieties.*—Two varieties grown were Globe and Tankard. The Globe cropped more heavily than the Tankard but the keeping quality of the Tankard is better, and the percentage dry-matter higher, than those of the Globe.

*Manuring.*—The application of heavy dressings of potash did not increase the yields. The application of Sulphate of Ammonia and Nitrate of Soda as a top dressing resulted in increased yields, Nitrate of Soda giving higher yields than Sulphate of Ammonia. Ammonium Humate and Humic Acid (Crowther and Brenchley, 1934) were both tested against Sulphate of Ammonia but gave lower yields.

HOPS AS A MANURE.

The very low price of hops in 1928 was stated to be due to the large stocks on hand and some were sold cheaply for manurial purposes. Trials were commenced to test their value as against farmyard manure. The hops were applied to potatoes and gave yields as good as farmyard manure. Hops used for litter for pigs made a manure of rather higher manurial analysis than that made with straw under the same conditions, especially noticeable was the potash. Swedes grown after the application of these manures showed the hop manure to be quite as satisfactory as the straw manure.

TEMPORARY SEEDS MIXTURES.

The introduction of temporary leys on arable land during the period of low corn-prices and the continuation of some of the leys for several years for grazing purposes were the reasons for the institution of a trial of Perennial Rye-Grass against Italian Rye-Grass and Broad Red Clover against Late-Flowering Red Clover. The results showed that the Perennial Rye-Grass gave as much hay in the first year as Italian Rye-Grass and was more permanent for the following years. Broad Red Clover was more satisfactory than Late-Flowering Red Clover because of the heavier aftermath. As both of these red clovers die out after the first year's two hay crops, the inclusion of Wild White Clover is useful.

PERMANENT GRASS SEEDS MIXTURE.

Twenty-nine plots were laid down with different seeds mixtures and different rates of seeding, and one was left unsown. Botanical analyses were taken in 1928-9-30. The plot left unsown was very rough with some bent grasses, but clovers soon established themselves from the surrounding plots. The sowing of mixtures of more than 30 lb. was shown not to be economic and heavy sowings of Wild White Clover were not necessary. All the types of red clovers sown soon died out and there appeared to be no reason for complicated mixtures to be used. Perennial Rye-Grass with Wild White Clover and a bottom grass, such as Rough Stalked Meadow Grass or Crested Dog's-tail, was all that was necessary. By the end of 1930 all the plots were of a similar composition.

INTENSIVE GRAZING.

A trial was carried out on the scheme devised by the Imperial Chemical Industries. Sheep were fed on unmanured grass and some on grass manured with a basal dressing plus nitrogen, other sheep were fed on six small plots of grass manured with a basal dressing and an application of nitrogen at frequent intervals. The sheep were grazed for a short period on each of six plots. The results showed that the sheep fed on the six plots did not thrive as well as those on the manured free range plot.

PERMANENT PASTURE MANURING.

The application of potash and North African phosphate to the grass land on the College Farm has shown little return, whereas the use of basic slag has been very beneficial. To test the comparative values of North African phosphate and basic slag sheep were fed on plots treated with these two manures. The sheep on the slag plot gained more weight than those on the North African phosphate plot.

NITROGEN MANURING FOR EARLY GRASS.

These trials were judged on observations only and the results were not conclusive, as in some years the month of February was very dry and the effect of the nitrogenous manures was not plainly visible. When the seasons were suitable the nitrogen treated plots were about a week ahead of the untreated. The manures used were Sulphate of Ammonia, Nitrate of Soda, Calcium Cyanamide, Nitro-Chalk and Urea, and they were applied at the beginning of February.

ROMNEY MARSH GRASS LAND.

A trial was carried out on the Romney Marsh as a part of a large experiment including many parts of Great Britain. A Pasture Investigation Committee was in charge. A botanical analysis showed the field to be mainly Perennial Rye-Grass with some Rough Stalked Meadow Grass and Bent grasses. Wild White Clover was only 2 per cent. The pasture was placed in the highest grade by the Committee (Report, 1932). Manuring was carried out by a basal dressing of lime, phosphates and potash and frequent applications of nitrogen added. Even on this very rich pasture the yield of grass was increased by 2½ tons per acre each year. Samples of grass were taken every three weeks and analysis made for the dry matter, nitrogen, phosphoric acid, potash and lime.

GENERAL INVESTIGATIONS.

Investigations into farm management have also been carried out by the Farm Manager, Mr. N. V. Hewison, in collaboration with Mr. J. Wyllie of the Department of Economics.

*Sheep.*—The flocks included in the investigations were Dorset Horns, Kerries, Mashams, Kents, Cheviots and Border-Leicester-Cheviot cross or Half-breds (see Wyllie, 1931). The most satisfactory flock commercially was the Half-bred due to the high lamb yield and good milking capacity. The breeds just mentioned have been crossed with rams from the following breeds: Hampshire, Suffolk, Southdown, Border-Leicester, Kent and Dorset Horn. The cross found to be the most satisfactory for the local market was the Southdown × Border-Leicester-Cheviot.

Dairy Cows.

The establishment of a T.B. free herd and the eradication of contagious abortion from the herd have been improvements involving much work and study and have been carried out under the direction of the Veterinary Department. The cows are now in the fields all the year round, only coming into the shed for milking.

Heifers.

The production of Grade A (T.T.) milk has necessitated the rearing of all the heifer calves and these are tested by the tuberculin test at the age of 15 months and onwards. The cost of rearing heifers has been reduced by rearing them out in the fields with access to a covered yard and by feeding the cheapest ration consistent with maintenance and thrifty growth.

Fattening Stock.

The low prevailing market prices make it impossible to fatten stock in yards or on the grass on these farms at an economic figure. The only stock fattened are the heifers and cows drafted out.

Arable Land.

The depression in corn prices between 1927 and 1932 led to the introduction of three years leys and an increase in the breeding flock.

Leys.

Many different mixtures of grasses and clovers were sown, based on the results of the trials previously mentioned in this paper. The mixture now used consists of Perennial Rye-Grass, Broad Red Clover, Wild White Clover, and Crested Dog's-tail or Rough Stalked Meadow Grass, and this has given excellent swards.

Crops Introduced.

The growing of early potatoes proved these soils to be unsatisfactory for commercial production on a farm scale. Wild White Clover seed has shown satisfactory profits in suitable seasons. The production of Broad Red Clover seed was profitable when market prices permitted. Recently Peas for canning purposes have been introduced.

Conclusion.

It will be seen that these investigations into management have resulted from necessity under changing conditions (see Hewison and Wyllie, 1933), and that methods of rotations of crops, rationing and other theoretical requirements have been adapted to the prevailing conditions but that they have always been in the background for use as guiding principles.

The objects of the trials carried out have been various, some proving scientific principles, some as a guide to the management of our own farms, some to test new materials and others to combine with investigators to make their work more complete.

SUMMARY.

The field trials and investigations of the Agricultural Department for the years 1927-32 are summarized.

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# A METHOD TO DETERMINE THE SURFACE AREA OF TREES COVERED BY SPRAY FLUID AND TO OBTAIN A PERMANENT RECORD OF THE DEGREE OF FINENESS OF THE DEPOSIT

By CORNELIUS DAVIES.

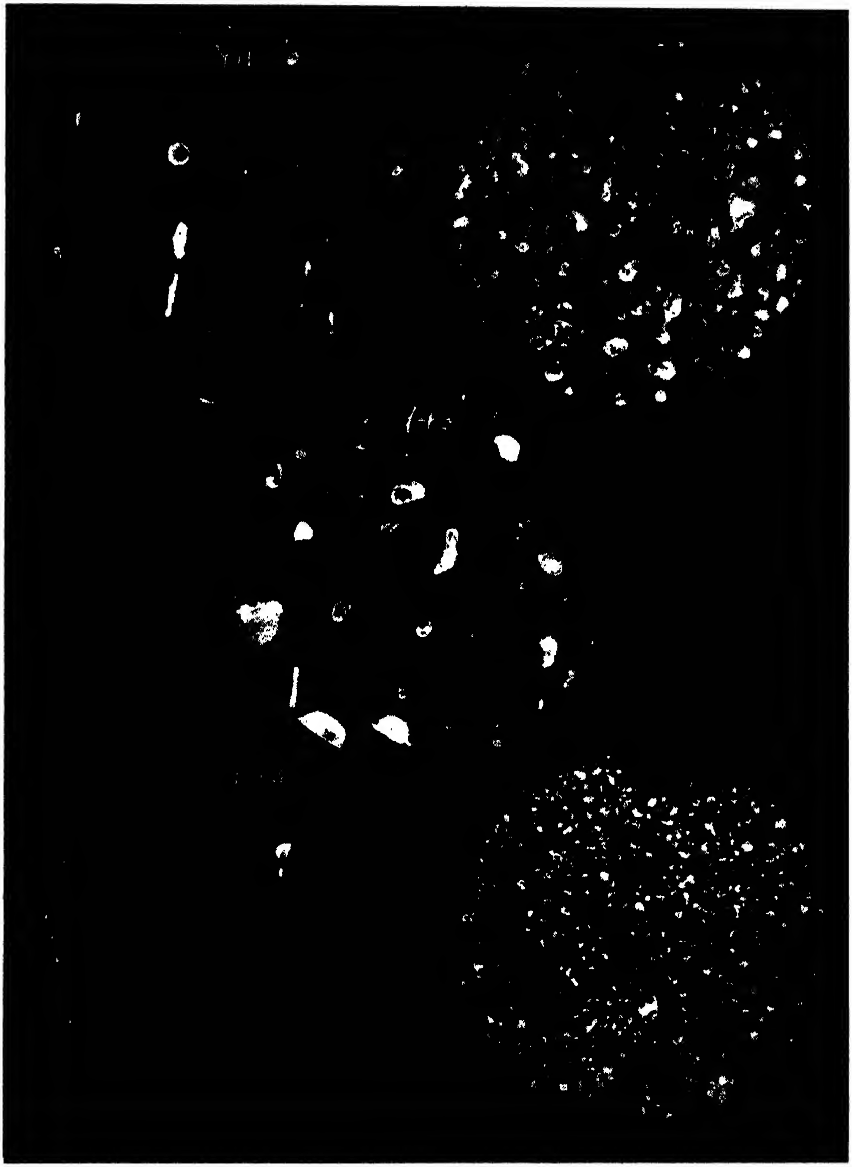
THE methods, discussed in this *Journal*, by means of which the spray cones ejected by nozzles under various conditions were studied in the laboratory are not applicable in the field, and it was necessary to evolve a technique whereby a fair measure of the amount of tree surface covered by spray liquids could be determined, and also to ascertain to what extent the results obtained in the laboratory are reproduced under actual growing conditions. The collection and examination of a random sample of leaves, after spraying, was tried, but it was difficult and in some cases impossible to see the deposit when it was dry, and the preservation of the leaves—when the chemicals could be seen—in their pristine condition for later examination is tedious and unsatisfactory.

The method we are using is to place a number of artificial leaves, suitably randomized, in the tree and to collect them and study them at leisure. These artificial leaves take the form of discs 2 inches in diameter and made of transparent celluloid. Many different materials and colours were tried from which to make the discs, but clear celluloid has been found to be the most satisfactory. When sprays such as lime-sulphur and Bordeaux mixture are used on the celluloid discs it is more visible than on most of the other substances we tried, and it is generally possible to increase the density of the dried deposit, subsequently, by treating the discs with a suitable chemical which in itself leaves no visible precipitate, but combines with the chemicals already present. For example, celluloid discs sprayed with lime-sulphur will show a clearer pattern if they are immersed for a few seconds, when dry, in silver nitrate solution. Whether subjected to this after-treatment or not transparent discs having a visible covering of dry spray can then be used as negatives, and photographic prints taken from them for permanent record purposes, after which the discs can be washed and used again. The accompanying illustrations were obtained from discs hung in large Bramley's Seedling apple trees sprayed, with lime-sulphur without any spreader, dipped in strong silver nitrate, after the deposit had been wiped off one side, and printed on gas-light paper for about two seconds. It was determined by examination that the surface tension between the spray fluid and the leaves of this variety of tree was similar to that on untreated celluloid discs. It is necessary, however, in some cases to find by experiment if the discs collect the spray in the same way as the leaves, and if not to apply various transparent coatings, such as oil, to them until they are similar.

We have found that a convenient method of fixing the discs in the tree is to employ the small spring clips used to display price tickets in shops.

To determine with great accuracy the percentage of cover obtained a photo-electric-cell technique might be evolved; but at the moment we are doing this by eye.

Sincere thanks are given to those of our colleagues who so kindly gave advice on the several chemical and photographic problems which arose in connection with this method.



Five artificial leaves showing the kind of cover which was obtained in one part of an apple tree sprayed with lime-sulphur under commercial conditions.

# LABORATORY CHECKING OF CAPILLARY PIPETTES

By W. J. Ball and H. Barkworth.

Difficulty was experienced in checking the calibration of a batch of capillary pipettes. These pipettes were designed to measure ·1 c.cm., being graduated every ·01 c.cm., and the ·1 mark being approximately 3·3 cm. from the tip. The measurements of twelve pipettes selected at random from a one gross consignment are as follows :—

| | Maximum. | Minimum. | Average. |
|---|---|---|---|
| | cm. | cm. | cm. |
| Length from tip to zero mark .. .. .. .. | 16·0 | 12·3 | 13·8 |
| Length from tip to ·1 mark .. .. .. .. | 3·7 | 3·0 | 3·275 |
| Length from zero to ·1 mark .. .. .. .. | 13·0 | 9·2 | 10·53 |
| Approximate bore .. .. .. .. .. | | | ·11 |
| Overall length .. .. .. .. net | | | 27·5 |

Sucking up mercury by the mouth was laborious and neither the finger nor pressure tubing and a screw clip proved a sufficiently delicate means of adjusting the level. Immersing the pipettes in a test-tube of mercury was no improvement, as even when using a screw clip the level of the mercury inside the pipette fell as soon as the level outside was reduced. Finally an apparatus was arranged as shown in the sketch and operated as described below.

## Apparatus.

The butt end of the pipette was connected by pressure tubing to a short length of glass tubing incorporating a ground-in stopper, the tip of the pipette dipping into a basin of mercury standing on a movable block. Rigidity was attained by holding the pipette in a clamp and the farther end of the glass tubing was connected to a filter pump.

## Method.

1. Water is kept continuously running through the pump and the vacuum above the pipette is adjusted by means of the screw clip A until the mercury rises in the pipette at a convenient rate.

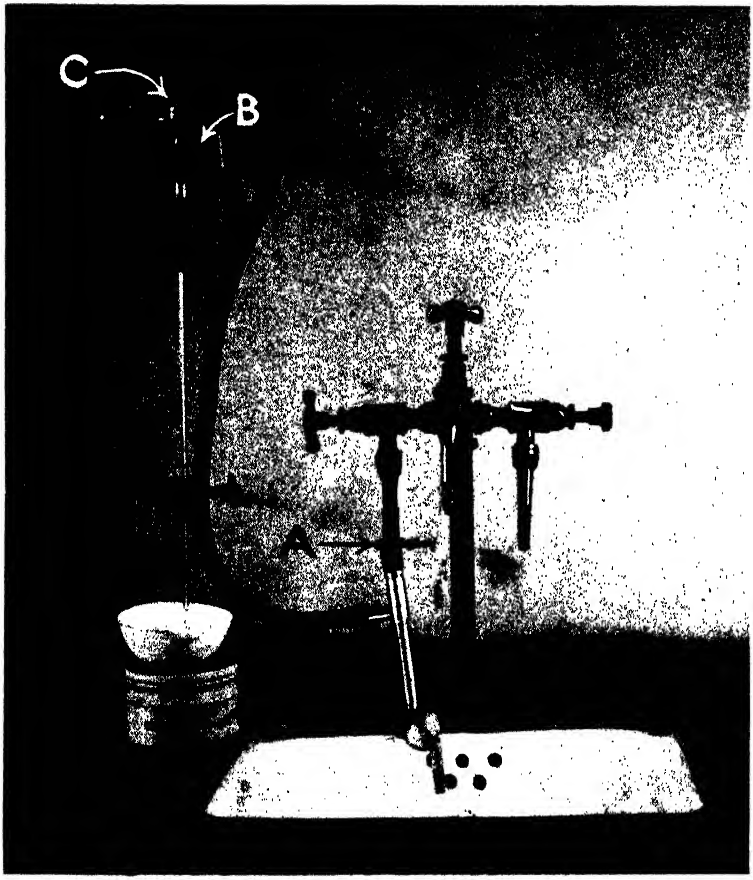
2. Cut off the suction with the tap B when the level of the mercury is just above the zero mark.

3. Obtain final adjustment by altering the level of the basin with one hand ; the finger of the other hand must at the same time be inserted into the mercury ready to cover the tip of the pipette when the correct height of the mercury in the bore of the pipette has been obtained.

4. Remove the basin, disconnect from the filter pump at C and run out the mercury into a weighing bottle of known weight taking care to empty the pipette completely.

5. Repeat as above raising the mercury only to the ·1 mark, and subtract the second weighing from the first.

Time should be allowed for the mercury in the basin to attain room temperature before commencing a series of weighings. Fluctuations of the temperature of the mercury in the basin will occur during a series, due to immersion of the finger, but the small amount in the weighing bottle may be considered to be at room temperature.




**Apparatus for checking capillary pipettes.**

# MEASURING 1/10TH C.CM. MILK

By W. J. BALL and H. BARKWORTH.

VAN OIJEN'S test for the total bacterial content of milk necessitates the direct measurement of 1/10th c.cm. milk and it might be questioned whether this could be done with adequate accuracy. As a check twelve pipettes were taken at random from a batch of one gross supplied for Van Oijen's test by a regular maker. The pipettes have two marks, the top mark being about 13·8 cm. and the bottom mark about 3·3 cm. from the tip. This leaves a space of about 10·5 cm. for the 1/10th c.cm. volume and gives an approximate bore of ·11 cm. Accuracy was checked by multiple weighings of the amount delivered by each pipette, using both mercury and milk. The technique of the mercury method has been described in detail elsewhere. Three weighings were made for each pipette from the top mark and three from the bottom mark giving nine possible differences. With milk, only three direct weighings per pipette were made, it being of course possible to check the discharge of the fluid at the lower mark. The specific gravity (1·0335) was taken with a Westphal balance. Fat content was 3·45 per cent (Gerber). The sample was shaken twenty-five times at the outset, inverted twice before each subsequent weighing, and shaken six times before each fresh pipette. A look-out was kept for gross air bubbles in the column of milk in the pipette, as is always done, but the chief aim was to imitate as closely as possible, the conditions of measurement of milk pertaining when samples are undergoing routine bacteriological testing by the Van Oijen method, and the authors claim that the accuracy attained in these check weighings is reproduceable under everyday conditions.

## RESULTS.

The results of the check weighings are summarized in Tables IA and IB. Table IB shows that an error, though slight, is caused by the use of double weighing of the mercury technique, and internal evidence suggests that most of this error is associated with the lesser weights (from lower mark to tip). From both tables it is plain that a single pipette, No. 6, is responsible for most of the error. The excess of the mean mercury weighings in Table IA ( +·41% and +·65%) is not statistically significant, but inasmuch as eleven out of the twelve pipettes give mean weighings slightly in excess of the true there is a probability that either the method or the calibration are in excess. Comparing the milk and mercury it appears that the pipettes are correct for mercury but deliver short weight of milk.

1/10th c.cm. PIPETTES. RESULTS OF CHECK WEIGHINGS.

TABLE IA.

*Percentage Error of Mean Weighings against True Weight.*

| Detail. | Mercury (each pipette mean of 9 weighings). | | | Milk (each pipette mean of 3 weighings). | | |
|---|---|---|---|---|---|---|
| | Max. | Min. | Mean. | Max. | Min. | Mean. |
| | % | % | % | % | % | % |
| 12 pipettes .. .. .. | +1·05 | −2·20 | +·41 | −7·43 | −2·24 | −3·16 |
| Less No. 6 .. .. .. | +1·05 | + ·20 | +·65 | −3·27 | −2·24 | −2·78 |

### TABLE IB.
*Analysis of Variance.*

| Detail. | Mercury. | | Milk. | |
|---|---|---|---|---|
| | All 12 pipettes (108 weighings). | Less No. 6 (99 weighings). | All 12 pipettes (36 weighings). | Less No. 6 (33 weighings). |
| | % | % | % | % |
| Error between pipettes (due to calibration) .. .. | 2·57 | ·74 | 2·50 | nil |
| Error between weighings (due to weighings) .. .. | ·29 | ·16 | nil | nil |
| Uncontrolled error .. .. | ·18 | ·15 | ·67 | ·7 |

Table 1B.—The standard deviations are expressed as a percentage of the data mean.

## CONCLUSIONS.

1/10th c.cm. milk can be measured with absolute accuracy (as required in Van Oijen's test) but the pipettes as supplied deliver about 2·78 per cent by weight short of milk.

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# NOTES ON DIPLOPODA III.

## SHORT NOTES ON THREE INJURIOUS MILLIPEDES RECENTLY OBSERVED

By SHOLTO W. ROLFE, B.Sc. (Agric.), Dip. Agric. (Wye),
*Department of Zoology and Geology.*

*Choneiulus palmatus* (Nemec) ON MUSHROOMS.

On 5 April 1934 a few small mushrooms just past the "button" stage were sent in to the Department of Advisory Entomology of the College by Mr. E. Frampton, of East Preston, Sussex. The mushrooms were found to be attacked by mites, springtails and millipedes. The last-named on examination of the gonopods of a male, proved to be referable to the species *Choneiulus palmatus* (Nemec). The animals had eaten out considerable holes in the mushrooms in the manner characteristic of the Blaniulidae. Over a dozen specimens, males and females, were present in the three or four mushrooms received, but there was no evidence as to how representative this was of the whole attack. The record is of interest as this millipede has only rarely been recorded for England and then never to the writer's knowledge, as a pest.

*C. palmatus* may be distinguished from the common Spotted Snake Millipede, *Blaniulus guttulatus* (Bosc) and from *Archiboreoiulus pallidus* (Brade-Birks) by the fact that the spots on the sides of the body are not red as in *B. guttulatus*, or orange as in *A. pallidus* but dark brown. The whole body is light brown unlike the other two species which are almost white. *C. palmatus* varies from 9·0 to 12·0 mm. in length thus being somewhat smaller than *B. guttulatus* which varies from 10·0 to 18·0 mm. in length. But, for definite diagnosis, in each case it is necessary to examine the gonopods of a mature male animal.

*Blaniulus guttulatus* (Bosc) ON PEAS.

Peas of the variety "Lincoln" were planted in the Park Field, Wye on 22 March 1934. When they came up bad gaps were noticed in the rows, in many places over three feet long. The time of planting was by contract and, in fact too early for this particular variety of pea and this may, in part, account for the failures but there is little doubt that millipede attacks have at least been a contributory cause. At the time that the young plants were coming through the ground seeds in some of the gaps were dug up and examined and millipèdes of the species *Blaniulus guttulatus* were found to be feeding in fair numbers between the cotyledons. At the time of writing (8 May 1934) the plants that have grown are about three inches high and will in all probability grow away from any attack, though millipedes are still to be found feeding on and boring into the cotyledons of the seeds.

This species is more often recorded as a pest than any other millipede and has been known to attack a number of agricultural and horticultural crops.

*Cylindroiulus londinensis* var. *caeruleocinctus* (Wood) ON STRAWBERRIES.

Strawberry plants which had been treated with hot water (110° Fahr. for 20 min.) were planted on 5 April 1934 among the fruit trees in field " C ", Wye. Within about three weeks many of the plants were noticed to be rather sickly and in some cases they had completely died off. Most of the dead and sickly plants examined were found to have millipedes of the variety *Cylindroiulus londinensis* var. *caeruleocinctus* among the roots at a depth of about three inches. Probably these animals were a serious cause of the death of a number of the plants even though they may only have attacked roots which were already in an unhealthy condition. This supposition is supported by the fact that the roots of the comparatively healthy plants were short and browned at the tips as though partially rotten, this is thought to have been due to the hot water treatment. It is well known that this millipede prefers decayed or decaying vegetable material for its food.

This variety of millipede is a dark brown, tail-less animal which reaches a length of 1½ inches. It is quite common in Kent.

# SUDDEN OUTBREAKS OF INSECT PESTS

By H. F. BARNES, M.A., Ph.D.

*Department of Entomology, Rothamsted Experimental Station, Harpenden, Herts.*

THE numbers of insects fluctuate from time to time. Occasionally there is an outbreak of a particular pest in enormous numbers; on the other hand, an insect pest is sometimes conspicuous because of its apparent complete absence. The investigation now in progress at Rothamsted is designed primarily to collect data of these fluctuations. The object of obtaining such data is to enable the causes of the fluctuations to be discovered. The ultimate aim of the work is to determine whether or not it is possible to predict outbreaks of insect pests.

## A.—ESTIMATION OF INSECT POPULATIONS.

Before being able to study sudden increases or decreases in insect numbers, it is necessary to obtain reliable means of estimating insect populations. Two such methods are receiving attention, namely 1, Direct Sampling of the Crop and counting the insects present and 2, Trapping Insects.

### 1. DIRECT SAMPLING AND COUNTING.

The insects chosen to be investigated have up to the present been the gall midges (*Cecidomyidæ*) on account of their diverse habits, their prevalence and the ease in obtaining large numbers. Six gall midges are being studied, two living on wheat, one on Meadow Foxtail grass, one on willows grown for basket making, one causing terminal leaf roll on pear trees and one living on Arabis.

The method adopted has been to sample a crop and count the numbers of injurious insect larvae present. This gives a figure for the *Infestation of the Crop* and from this the actual amount of damage to the crop can be ascertained. In Table 1 are given the numbers of larvae of *Contarinia tritici* Kirby present in 500 ears of wheat collected on Broadbalk field at Rothamsted in the years 1927-33.

TABLE 1.

*Numbers of larvae of* Contarinia tritici *Kirby present in* 500 *ears of wheat on Broadbalk,* 1927-33.

| 1927. | 1928. | 1929. | 1930. | 1931. | 1932. | 1933. |
|---|---|---|---|---|---|---|
| 1,780 | 2,195 | 19,265 | 18,595 | 19,273 | 7,356 | 1,511 |

In Table 2 similar figures are given for *Sitodiplosis mosellana* Géhin, another gall midge attacking wheat.

TABLE 2.

*Numbers of larvae of* Sitodiplosis mosellana *Géhin present in* 500 *ears of wheat on Broadbalk,* 1927-33.

| 1927. | 1928. | 1929. | 1930. | 1931. | 1932. | 1933. |
|---|---|---|---|---|---|---|
| 715 | 2,043 | 587 | 3,746 | 6,027 | 3,114 | 319. |

It will be seen that the numbers of insects present vary considerably from year to year. In the case of *C. tritici* while only 1,780 larvae were obtained in 1927 as many as 19,265 were present in 1929 ; in other words nearly eleven times as many insects. The same type of increase takes place in *S. mosellana*; for example in 1931 over 6,000 larvae were present, while in 1933 only 319 were obtained.

The larvae of *C. tritici* prevent the formation of the grain and so the damage for 1927-33 due to this insect can be expressed as a percentage of the total number of grain or corn in the crop. In Table 3 this percentage is set forth as well as the actual number of grains lost.

TABLE 3.

*Percentage grain attacked and numbers of lost grain on Broadbalk,* 1927-33, *due to the larvae of* C. tritici.

| | 1927. | 1928. | 1929. | 1930. | 1931. | 1932. | 1933. |
|---|---|---|---|---|---|---|---|
| Percentage Grain attacked .. | 0·95 | 0·79 | 5·9 | 5·9 | 6·4 | 4·9 | 0·65 |
| Number of Lost Grain in 500 ears | 239 | 203 | 1,434 | 1,394 | 1,701 | 1,039 | 125 |

The larvae of *S. mosellana* cause shrunken grain and the actual numbers of affected grain as well as the percentage grain attacked on Broadbalk during the last seven years are shown in Table 4. The larvae of *C. tritici* are gregarious while those of *S. mosellana* are not. This accounts for the large numbers of *C. tritici* larvae recorded and comparatively few grains lost. Whereas in the case of *S. mosellana* comparatively few larvae cause a relatively large number of grains to be shrunken.

Having obtained the larvae it is the practice to rear them to the adult stage. In the case of the wheat midges emergence of the adults does not take place till the following spring.

TABLE 4.

*Percentage grain attacked and numbers of lost grain in* 500 *ears on Broadbalk,* 1927-33, *due to the larvae of* S. mosellana.

| | 1927. | 1928. | 1929. | 1930. | 1931. | 1932. | 1933. |
|---|---|---|---|---|---|---|---|
| Percentage Grain attacked .. | 2·2 | 5·7 | 1·8 | 11·7 | 15·0 | 10·5 | 1·4 |
| Number of Shrunken Grain .. | 541 | 1,486 | 434 | 2,760 | 4,032 | 2,260 | 273 |

As the injurious insect larvae are nearly always parasitized, a number of parasites will emerge as well as the injurious gall midges. Thus this part of the work provides information on the *Degree or Extent of Parasitism.* Two examples are given in Table 5.

TABLE 5.

*Degree of Parasitism of* C. tritici *and* S. mosellana, 1928-32.

| | 1928-9. | 1929-30. | 1930-1. | 1931-2. | 1932-3. |
|---|---|---|---|---|---|
| *C. tritici* .. .. .. | 9·5% | 27% | 53% | 45% | 73% |
| *S. mosellana* .. .. | 73% | 43% | 85% | 85% | 85% |

Although these figures of parasitism have on occasion been high, weather conditions seem to play a more important part in sudden fluctuations of insect numbers. For example, in 1933 the spring was early and the wheat midges *C. tritici* and *S. mosellana* emerged three weeks earlier than usual, and although the wheat was also earlier than normal the emergence of the midges did not coincide with that of the ears of wheat. As the midges live only for a day or two and as they oviposit in the freshly emerged wheat ears, this maladjustment of insect and plant had a big result. In 1933 the attack of the two midges on the wheat was reduced to about 2 per cent grain infestation instead of about 15 per cent in 1932.

Besides obtaining the degree of parasitism, the breeding of the insects gives data of the *Emergence Dates* of the insects. These dates are of great importance as may be seen from the above remarks concerning the wheat midges in 1932 and 1933.

## 2. TRAPPING INSECTS.

Some insects are attracted to light; other insects are attracted to chemicals. Making use of this knowledge, Dr. C. B. Williams is developing and constructing various types of insect traps as a means of assessing the numbers of insects from year to year. In this way data will be accumulated, and this should provide information as to the comparative abundance of insects. In addition, it is hoped to discover the relation of insect activity to atmospheric conditions such as temperature, humidity, cloudiness, etc.

As a beginning a light trap (Plate I) has been devised in order to measure the degree of activity of insects by night. The principle of this trap is that insects are attracted to light. Plate I illustrates the trap. It consists briefly of an electric light surrounded by glass with a small space to allow the admittance of the insects. A funnel leads down from the light to a set of eight killing bottles. There is a clockwork mechanism which brings the bottles, one at a time, immediately below the funnel. This mechanism allows the bottles to be brought into position at any fixed time and so the night's captures are automatically sorted into eight bottles representing eight periods of the night. At present these periods are equal but are adjusted to vary in length according to the season of the year, as the nights grow longer so the period that each bottle is in action lengthens. Large numbers of diverse insects have been captured and it is hoped that after running the trap for a period of years data will have been collected illustrating the fluctuations in numbers and activity periods of insects. In the meantime much valuable data is being obtained and from these, attempts are being made to correlate the activities of insects, as measured by the light trap captures, with atmospheric conditions.

Naturally all insects are not attracted to light and so other traps will have to be devised in order to obtain data concerning the activities of insects which can only be caught by other methods.

PLATE I.

Light trap, with side removed to show the eight bottles and mechanism for changing their position.

Having obtained data as to the fluctuations in insect numbers, it may be possible in the future to predict outbreaks of insect pests. Such forecasts would be of the greatest importance in control work. Fig. 1 shows one such prediction, based partly on observations and partly on direct counts, concerning the wheat blossom midges (*Contarinia tritici* and *Sitodiplosis mosellana*).

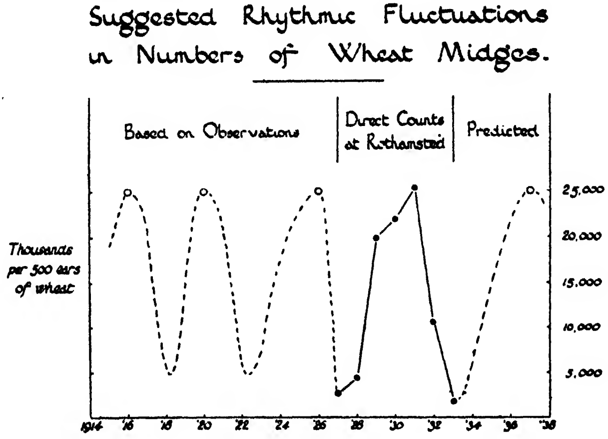



Fig. 1.

## B.—AVOIDANCE OF EPIDEMICS OF INSECT PESTS.

In the meantime epidemics of insect pests may sometimes be avoided by the following precautions: (1) the Choice of Suitable Soil and Position for the Plant, (2) the Use of Resistant and Immune Varieties of Plant and (3) the Suppression of Alternate Host Plants of the Pest, for example, weeds. In fact, *cultural methods of control* are the main methods of keeping insect pests down to reasonable numbers.

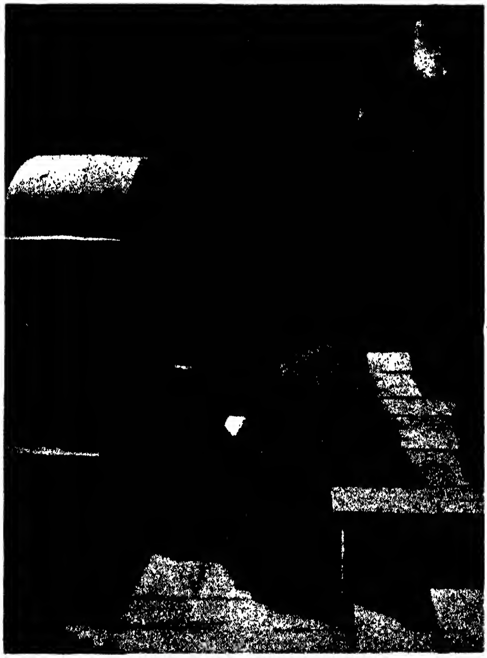
One serious drawback however must be emphasized. If the optimum conditions for the welfare of the plant and the insect are the same many cultural methods are not advisable, and, one has to decide whether it is preferable to have a good crop with the risk of pest flourishing or to have a mediocre crop with the insects absent or present in low numbers. This is largely dependent on the market value of the crop. In the former case one must resort to the use of insecticides as a palliative. Fortunately however very often the optimum conditions for the plant do not coincide with those for the pest and in such cases, cultural methods are of the utmost importance.

### 1. The Choice of Suitable Soil and Position for the Plant.

The correct soil and position for the plant is essential to avoid insect attack in some cases. If the plant can be maintained in good health, it will often escape insect attacks or else be able to suffer attack without serious damage resulting.

As an example of this a recent case concerning a Lavender hedge can be mentioned. Lavender is not usually subject to caterpillar damage, but a hedge (Plate II) planted in a shady and badly ventilated position was found to be infested with at least twelve different kinds of caterpillars and some of these were present in large numbers and

Plate II.




Lavender hedge.

doing considerable harm. Nearly all the caterpillars belonged to species which are general feeders and yet have never before been recorded as attacking lavender. It seems highly probable that there is some connexion with this caterpillar attack and the ünfavourable position of the hedge.

2. The Use of Resistant and Immune Varieties of Plants.

Some varieties of plants are *tolerant* of insect attack, others are *truly resistant*. Resistant plants may be resistant for a number of reasons. There are physico-chemical reasons such as thickness of cuticle, hairiness and the presence of alkaloids, essential oils, acids, gums and tannins. There are also physiological reasons such as plant vigour, early maturity, seasonal adaptation and the absence of response to specific stimuli.

Certain varieties of willows grown for basket making are liable to suffer injury by certain gall midges. Their grubs live in galls at the apex of the shoots and cause side branching. As the aim of the growers is to produce straight unbranched stems, or rods as the latter are called when peeled, such midges are decidedly injurious.

One line of work in the Entomology Department at Rothamsted has been to discover whether all varieties are equally liable to attack. The method used is illustrated in Plate III ; Fig. 1 shows a large muslin cage in which different varieties of willow are grown. Midges are placed inside the cage and allowed to choose the variety on which they prefer to lay their eggs. Thus this part of the trial is preferential. If one or more varieties are found to be unattacked (as in Plate III, Fig. 2), those varieties which are attacked are cut down and only the unattacked ones are left. Thus the trial becomes an immunity trial. It has been found that seven varieties are immune to attack by one kind of midge. Some of these immune varieties, however, are attacked by another kind of midge whose attack also causes side branching of the willow. This midge in its turn will not attack those varieties of willow which are susceptible to attack by the first midge. It has further been shown that a hybrid variety of willow is immune to attack by both kinds of midge.

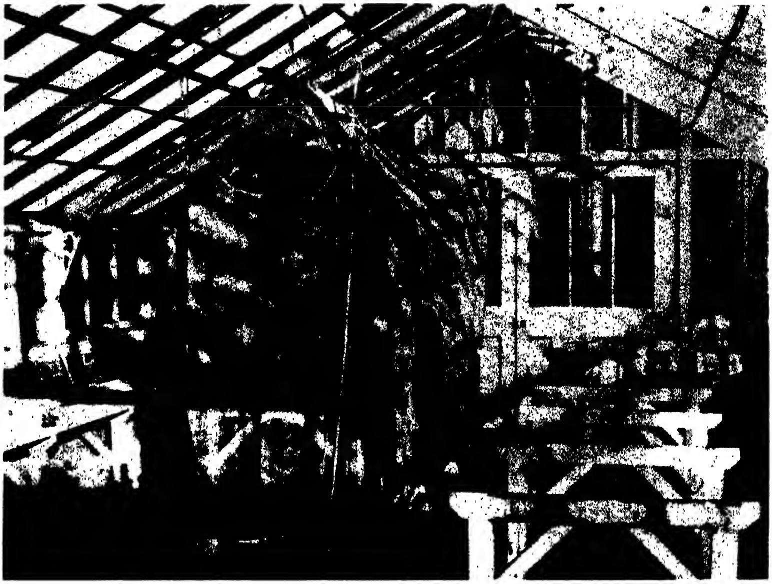
3. The Suppression of Alternative Host Plants of the Pest.

While no work on the actual suppression of alternative host plants is at present being carried out in the Department of Entomology at Rothamsted, an allied investigation of fundamental and far reaching importance has been undertaken by Mr. H. C. F. Newton.

As is well known many insects have more than one food plant and very often weeds are to be numbered among the host plants. It is for this reason that weeds should be suppressed. The term " weed " is used in the sense of any plant or variety of plant which is not desired to be the crop. This attractiveness of plants to insects is at present under investigation. It is here that the suppression of alternate host plants links up with the question of resistance or immunity of plants to insect attack, the one is complementary to the other.

The problem is to find out reasons why some plants are attractive to insects for the purpose of feeding and/or egg laying and why other plants are avoided by insects. The actual work being carried on in the department in this connexion can be divided into three sections—(*a*) what extent is the sense of smell used by insects in egg laying or food responses, (*b*) what organs of the insect are concerned in the reception of the odour stimulus and (*c*) what constituent of the plant is responsible for the stimulus.

PLATE III.



[*Courtesy of Cambridge University Press*]

Fig. 1. View of cage in which different varieties of willows were grown for testing their susceptibility to gall midge attack.

[*Courtesy of Cambridge University Press*]

**Fig. 2. Plants growing inside cage showing Harrison variety immune to attack.**

The whole of this section (3) of the work can therefore be entitled "Chemotropic Studies on Insects".

One method for discovering the relative attractiveness of different varieties of plants to insects is to use certain types of apparatus for determining the relative attractiveness of various plant odours to the insect in question. The insects are placed in an apparatus in one part of which there is one plant odour. Observations are then made to see to what extent the insects are attracted to it or repelled from it. In this way the relative attractiveness of various odours can be determined. As a consequence it should be possible in some cases to track down the attractiveness of certain plants to some constituent which is common to all the plants exhibiting this characteristic. For a better understanding of this, efforts are being made to discover what organs on the insects are responsible for the reception of this stimulus.

N.B.—We are obliged to the Cambridge University Press and to the Editors of the *Annals of Applied Biology* for the loan of the blocks for Plate III, Figs. 1 and 2.

# REVIEW

*Virus Diseases of Plants.* By JOHN GRAINGER. viii. + 104 pp. Oxford University Press, 1934. 6s. net.

The author's aim is to introduce to the student of plant pathology the phenomena associated with virus diseases. He commences with a brief introduction including a few historical particulars and then deals with the subject matter in six chapters : the relation of a virus to its host plant, some properties of viruses in extracts of cell sap, plant viruses and their insect vectors, economic effects of viruses and the methods of control, classification and description of a few virus diseases and finally some considerations of general experimental technique.

It was unfortunate for the author that by the time he had decided irrevocably that "a comprehensive volume would be inappropriate, as yet, and would have a limited use ", K. M. Smith's *Recent Advances in the Study of Plant Viruses* should have been published. Under the circumstances the specialist reader and research worker will prefer a fuller treatment of the subject than is contained in the present text, and on the other hand the horticulturist will desire more information upon the diseases of particular importance to him in place of the accounts of experimental technique. An elementary text book dealing comprehensively with virus diseases from the point of view of the grower would have provided a valuable supplement to existing text-books. Nevertheless a well printed and eminently readable little text has been produced at a reasonable price, and it will serve as an introduction to the subject for the general reader, who desires some knowledge of typical plant viruses and of the methods of studying them.

# A STUDY IN THE PROPAGATION OF APPLE TREES

By R. T. Pearl, W. Lamberton and J. L. Hunt.

The exhibit staged at the Kent County Agricultural Show, Ashford, July 1934, shows the various stages in the making of a young apple tree and gives some idea of the internal mechanism which regulates the growth of the tree.

It is well known that apple varieties are propagated vegetatively because they fail to " come true " from seed. The great majority of apples fail to establish themselves from cuttings or layers and it is necessary to resort to graftage, viz. the joining together of a ready made root system (rootstock) with the stem portion of the desired apple variety (scion). Now the root system is just as important as the part of the tree above ground and different rootstocks influence very differently the growth and cropping of the scion. Graftage is not only the surest method of multiplying an apple variety, but by a right choice of rootstock it also affords a valuable means of controlling tree size and crop. (Exact information is available on this aspect of the subject as a result of investigation at East Malling Research Station, to whom enquiries should be made.)

In the nursery the first step is the raising of the appropriate variety of rootstock, preferably by " stooling ". A permanent stool bed is established and the plants are cut down in Winter practically to ground level. This induces the growth of numerous shoots from the parent crown in the Spring and, by earthing up the stools somewhat similarly to potatoes, the young shoots form roots during the Summer. The soil is drawn away in the Winter and the rooted shoots cut from the stools for planting out in nursery rows for subsequent budding or grafting. (For practical details, see *Vegetative Propagation of Fruit Tree Rootstocks*, published by East Malling Research Station.)

These rooted stocks may be budded in the July following their removal from the stool, or if that fails they may be grafted in the subsequent Spring. The essential point is that the stock should make at least one season's growth in the nursery row, so that an adequate root system may be developed before any shoot growth is due to commence from the scion. The insertion of a bud does not interfere appreciably with root production, but the hard cutting back of the stem necessary in grafting restricts drastically the root system of a young stock. Any attempt to graft a newly planted stock would mean failure or at best a third-rate tree.

A study of the internal economy of the tree shows why this is so. With an ungrafted rootstock, the leaves appear early and they receive uninterrupted supplies of water and nutrients from the soil by way of the root system. By means of these supplies, brought upwards through the wood of the stem, the leaves build up the carbon foods (such as sugar and starch) necessary to the growth of the plant. Some of this leaf-made food is continually travelling down in the outer part of the stem (the bast) to the roots, where it is essential to the construction of new roots and the extension of existing ones. Stem and root materials are thus freely exchanged. After one season's growth a first-grade stock should possess an excellent root system capable of supporting sturdy shoots.

When a stem is cut back hard in the Spring and grafted, two things happen :—(*a*) the food- and water-conducting system is severed between stem and root ; (*b*) the leaf surface of the rootstock is entirely removed. It follows that there can be little or no exchange of materials between stock and scion until the union is thoroughly united,

and for some months the relatively small leaf system of the young scion will not be in a position to supply the large amounts of food which the rootstock would have received from its own leaf surface.

This process of joining together stock and scion is worth a close examination. First, it is important to note that the matched surfaces of the stock and scion, which are fitted together, consist mainly of dead wood which can never unite again. Each matched surface is, however, bordered with an active living tissue (the cambium) just below the outer rind. It is the soft greenish tissue which " slips " when the rind is peeled off the wood. Its usual duty is to produce new wood and bast, as the stem increases in girth. Nevertheless when two surfaces are brought together in grafting, the cambium begins to produce a soft healing tissue (callus), which at first forms an oval ring near the edge of the two matched surfaces but gradually spreads over the interface filling the crevices.

Briefly the stages which follow are : the knitting together of the young callus which takes about four to six weeks ; then the gradual formation in this callus of a ring of wood continuous with new wood formed simultaneously in stock and scion, which results in a quite firm woody union eight to ten weeks from grafting and allows water and nutrients to pass from root to stem in rapidly increasing quantities ; the bast unites also about this time and so at long last a supply of leaf-made food can again move downwards for the nourishment and growth of the roots.

It will be noted that there is a very marked check to early growth of the newly grafted tree whilst the union is developing, that the scion is very short of water for a month or so and the root is denied fresh food supplies for a considerably longer period. The need for taking precautions to restrict the demand for water is illustrated by : the bedding of scion wood in a shady place in mid-Winter, a practice which holds back scion growth at grafting ; the value of covering the union with waterproof material which prevents drying and hastens healing, and lastly the increased risk of failure if scions are at all dry. The temporary lack of food supplies to the root tends to restrict its early growth, but a well grown root has some reserves of food to tide it over this period. When, however, the root is not properly established before grafting the result is fatal, for it is impossible for the root to make much growth until the bast is re-established, whilst its associated lack of vigour actually tends to retard the formation of the union.

This is strikingly illustrated by the growth made by trees grafted on newly planted stocks as compared with that on well established stocks. On 3 April 1934, scions of Grenadier were grafted on stocks (Malling No. VII and XVI) planted in January 1933 and January 1934. Those planted in January 1933 had commenced to form new wood and a little bast across the union by the end of May and were firmly united and growing vigorously in late June, the root system was extensive and unchecked. Those planted in January 1934 had barely begun to form new wood in late June, the bast was only beginning to connect scion and stock and root growth was completely checked until this time owing to the absence of supplies from the scion. Thus the growth of root and shoot as well as the formation of the union have lagged a month behind the normal grafted tree.

In budding the union is very much simpler. The bud is inserted in July and the callus knits together during the Autumn. By the time growth is due to start next Spring the bud is firmly united to the stock in a manner practically identical with that of a bud growing there naturally. Growth starts at once and there is no check to the growth of either root or shoot, such as is experienced in grafting. Thus from the earliest stages the union is more complete and anatomically perfect than that obtained in grafting, there is little or no " dead " wood intervening between stock and bud with the result that the whole wood system, new and old, continues to operate quite normally. On the other hand it has been seen that in the act of grafting the original wood of both stock and scion is severed, never to unite again, with the result that this old wood plays little or no part after grafting either in strengthening the union or in assisting the transfer of supplies across it.

# INDEX

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